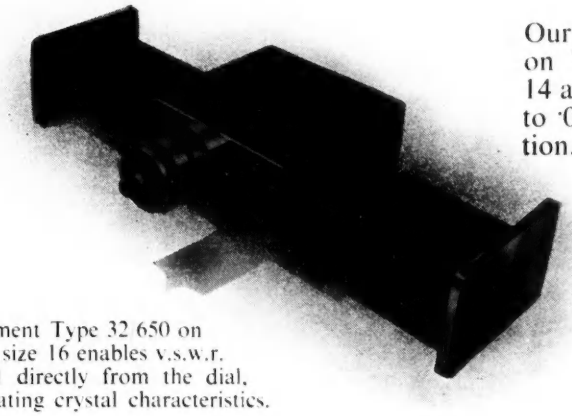
Electronic Engineering

PRECISION ATTENUATORS

for Microwave Measurements



Our range of instruments on Waveguide sizes 16, 14 and 10 are re-settable to ·002 mm in vane position.

Our instrument Type 32 650 on Waveguide size 16 enables v.s.w.r. to be read directly from the dial, thus eliminating crystal characteristics.

We manufacture waveguide components to customer's specification.

MICROWAVE INSTRUMENTS LTD.

WEST CHIRTON INDUSTRIAL ESTATE, NORTH SHIELDS, NORTHUMBERLAND, ENGLAND

Telephone : N. Shields 2817. *Telegrams : Microwaves, N. Shields.*

R v.27' Ja-Je '55

DATA for the Designers File

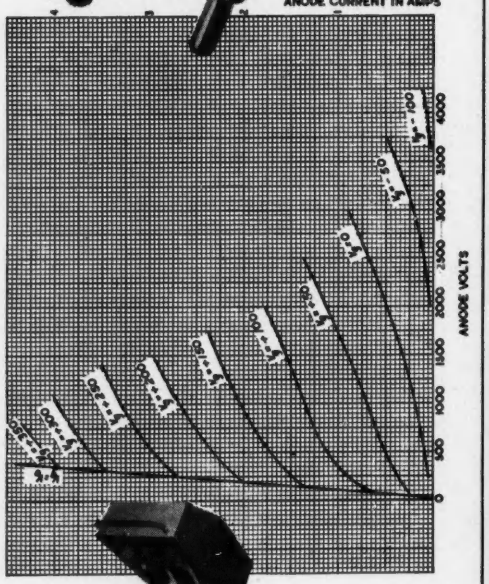
The Ediswan ES.833 is a high mu triode particularly suitable for use as an R.F. Power Amplifier, Oscillator or Class B modulator, and is an excellent valve for industrial R.F. heater equipment.

The anode and grid connections are brought out at the top and are taken through metal to glass seals to heavy current terminals. As a result of this construction the valve is exceptionally efficient at higher radio frequencies and may be operated under class 'C' CW conditions at a maximum input of 2kW at frequencies up to 30 Mcs. At reduced input rating it is possible to operate the valve as high as 75Mcs.

RATING

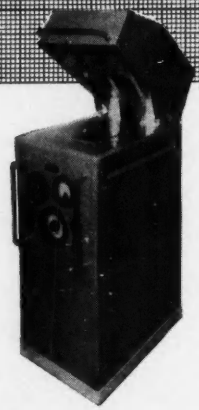
Filament Voltage (volts)	V_f	10.0
Filament Current (amps)	I_f	10.0
Maximum Anode Voltage (volts)	$V_{a\,(max)}$	*4,000
Maximum Anode Dissipation (watts)	$W_{a\,(max)}$	*400
Amplification Factor	μ	35
Maximum Operating Frequency at full rating		*30 Mc/s

* *Additional cooling will be required when operated at Full ratings at maximum Frequency.*
At higher frequencies anode voltage and input must be reduced.



REDIFON 1¼ KW H.F. Plastic pre-heater uses an ES.833 Oscillator.

This new industrial heater will plasticise up to 16 oz. of general purpose moulding powder preforms per minute. Output of this equipment is 1.3kW at 18 Mc/s.



EDISWAN

INDUSTRIAL AND TRANSMITTING VALVES

THE EDISON SWAN ELECTRIC CO. LTD.
155 CHARING CROSS ROAD, LONDON, W.C.2
Member of the A.E.I. Group of Companies

EV 134

Tech

ES
ANODE VOLTS
955

.FIED ANNOUNCEMENTS

The charge for these advertiseme... 'NE RATE (if under 1" or 12 lines) is: Three lines or under 7/6, each additional line 2/6. (The line averages seven words.) Bo... .r 2/- extra, except in the case of advertisements in "Situations Wanted," when it is added free of charge. At the INCH RATE ...ver 1" or 12 lines) the charge is 30/- per inch, single column. Prospectuses and Company's Financial Reports £14. 0s. 0d. per column. Are mittance must accompany the advertisement. Replies to box numbers should be addressed to: "Electronic Engineering," 28, Essex Street, Strand, London, W.C.2. Advertisements must be received before the 14th of the month for insertion in the following issue.

OFFICIAL APPOINTMENTS

ADMIRALTY: TECHNICAL CLASSES. The Civil Service Commissioners announce a supplementary Reconstruction Competition for men to fill three posts as Development Assistants at the Admiralty Engineering Laboratory, West Drayton, Middlesex. The duties involve experimental and development work in connexion with the electrical equipment of warships. Candidates must possess H.N.C. in Electrical and/or Mechanical Engineering or an acceptable equivalent. They must normally have served an engineering apprenticeship or its equivalent, followed by four years' adult experience. Salary scale £650 (at age 30) to £761. Starting salary according to age, e.g., £550 (at 25) up to £761 (at 36 or over). Promotion prospects. Further particulars and application forms from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S262/55. Completed application forms must be returned by 12th January, 1955. W 2705

AN ELECTRONIC TECHNICIAN is required by St. Bartholomew's Hospital, London, E.C.1. Duties involve servicing, planning, construction and testing of electronic equipment used in radioactive and radiation assaying and in other applications to medicine. Salary according experience in the Medical Laboratory Technicians scale of £450 × £15 to £515, plus London Weighting. Applications together with references to The Clerk to the Governors marking envelope "Electronic Technician." W 2648

BATTERSEA POLYTECHNIC, LONDON, S.W.11. Applications are invited from graduates of a British University for the following posts: Senior Lecturer in Telecommunications with good industrial experience. Grade B. Lecturer in Electrical Engineering with industrial experience. Salary in each case in accordance with the Burnham Technical Scale for London, less statutory deductions: Senior Lecturers: Men: £1,101 or £1,113 × £25—£1,263. Grade B: Men: £621 or £633 × £20—£928 plus £30 for a good Honours Degree and an allowance of £18 for 3 years', £36 for 4 years', and £54 for 5 years' training, plus increments for industrial and research experience. Further particulars from the Clerk to the Governing Body, Battersea Polytechnic, London, S.W.11, by whom applications should be received as soon as possible. W 2654

CHELSEA POLYTECHNIC, Manresa Road, S.W.3. Department of Physics. Head of Department: Dr. W. H. George, M.Sc., Ph.D. (Lond), F.Inst.P. Applications are invited for the post of full-time Senior Lecturer (or Lecturer) in Physics. Candidates should possess teaching, research and/or industrial experience in electronics. Ample time and facilities for research will be provided. The successful candidate will be graded as Senior Lecturer or Lecturer in accordance with qualifications and experience. The salary scales attaching to these grades are as follows: (a) Senior Lecturer: Men £1,065—£25—£1,215 p.a. Women £852—£20—£972 p.a. plus London allowance of £36 or £48 according to age. (b) Lecturer: Men £965—£25—£1,065 p.a. Women £772—£20—£852 p.a. plus London allowance. Placing on the scale will be in accordance with previous service in a similar capacity. Further particulars and form of application may be obtained by sending a stamped addressed foolscap envelope to the Clerk to the Governors. Applications should be submitted as soon as possible. W 2670

COLLEGE OF TECHNOLOGY, Birmingham. Department of Physics and Mathematics. There is a vacancy for a Research Assistant to take part in the development of an electronic aid for the blind. Experience in the design of electronic circuits is essential and practical acquaintance with television or sound-film recording techniques would be an advantage. Candidates must also have a good honours Degree in Physics preferably from a University which will award higher Degrees externally. Applicants will be expected to undertake a certain amount of teaching. Salary will be in accordance with the Burnham (Further Education) Scale for Grade "A" Assistants. Basic salary (Men) £510 with increments for approved training and industrial or teaching experience. Further particulars and form of application may be obtained from the Registrar, College of Technology, Suffolk Street, Birmingham, 1, on receipt of a stamped addressed foolscap envelope. Completed forms should be returned not later than two weeks after the appearance of this advertisement. K. R. Pilling, Clerk to the Governing Body. W 2727

ELECTRICAL ENGINEERS required by Ministry of Supply for various Research and Development Establishments including Royal Aircraft Establishment, Farnborough, Hants, Radar Research Establishment, Malvern, Worcs, Armament Research and Development Establishment, near Sevenoaks, Kent, and London H.Q. Experience in light electrical or electronic engineering fields desirable for the older candidates. Posts are graded (a) Scientific Officer, for which 1st and 2nd class Hons. Degree or equivalent is required; (b) Experimental Officer or Assistant Experimental Officer which require Higher School Certificate (Science) or equivalent but H.N.C. or Pass Degree may be an advantage. Salary within ranges: S.O. £470-£855 (London), £445-£815 (Provinces), E.O. (min. age 26) £720-£890 (London), £690-£850 (Provinces), A.E.O. £290 (age 18)—£645 (London), £276-£615 (Provinces). Women somewhat less. F.S.S.U. benefits may be available for S.O. grade. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.607/54-A. Closing date 14th January, 1955. W 2704

ELECTRONICS ENGINEERS AND PHYSICISTS required by Ministry of Supply, Radar Research Establishment, Malvern, Worcs; Signals Research and Development Establishment, near Bournemouth, Hants; Armament Research and Development Establishment, near Sevenoaks, Kent; Royal Aircraft Establishment, Farnborough, Hants; and outstations, and London H.Q. Duties include research, development or design of telecommunications and radar equipment and guidance and control systems, instrumentation for variety of research problems. Experience of V.H.F.; pulse techniques; display systems, etc., desirable for some posts. Appointments according to qualifications, age and experience, Scientific Officers (1st or 2nd class Honours Degree); Experimental Officers and Assistant Experimental Officers (Higher School Certificate (Science)) or equivalent; pass Degree, H.N.C. or C. and G. Full Technological Certificate may be an advantage). Salary within ranges. S.O. £445-£815; E.O. (minimum age 26) £690-£850; A.E.O. £276 (age 18) £615. London rates £14 to £40 higher. Women somewhat less. F.S.S.U. benefits may be available for S.O. grade. Application forms from M.O.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.596/54-A. Closing date 14th January, 1955. W 2703

MINISTRY OF SUPPLY, Radar Research Establishment, Malvern, Worcs, requires Electrical Engineers and Physicists for research and development work on radio and electronic equipment. Work ranges from fundamental research on circuitry and physics of solids, to devising and developing, in collaboration with Industry, electronic devices for the Army, R.A.F. and Naval Aviation. Ample scope for initiative and originality over very wide field concerned mainly with electronics. Minimum qualification Higher School Certificate (science) or equivalent, but further training in physics or electronic engineering to H.N.C. or Degree standard may be an advantage. Salaries within ranges, Experimental Officer (min. age 26) £690-£850, or Assistant Experimental Officer £276 (age 18—£615). Women somewhat less. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A 330/54A. W 2622.

MINISTRY OF SUPPLY. require for Radio Division, Royal Aircraft Establishment, Farnborough, Hants. (1) Scientific Officer—Physicist with good mathematical background to study application of titanate ceramics and similar materials to radio frequency problems. An interest in physics of the solid state is required and electronics experience desirable. (II) Senior Scientific Officer or Scientific Officer—Electrical Engineer or Physicist for research on special radio transmitting systems, in particular concerned with microwave region and with studies of modulation characteristics and frequency spectra. Quals.—1st or 2nd class honours Degree or equiv. For senior grade a minimum of 3 years post graduate research experience is essential. Salary within ranges—Senior Scientific Officer (min. age 26)—£935-£1,090 p.a. Scientific Officer—£445-£815 p.a. Women somewhat less. F.S.S.U. benefits may be available. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A 353/54A. W 2728

PHYSICISTS AND ELECTRICAL ENGINEERS required by Ministry of Supply, Radar Research Establishment, Malvern, Worcs, for research and development work on radio and electronic equipment, offering ample scope for initiative and originality over a very wide field concerned mainly with electronics. Posts are graded as Scientific Officer and require 1st or 2nd class Hons. Degree or equivalent qualification in Physics or Electrical Engineering. Salary within range, £445-£815. Women somewhat less. F.S.S.U. benefits may be available. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A 356/54A. W 2729

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY, Fort Halstead, Kent, requires an Electrical Engineer/Physicist in the grade of Senior Experimental Officer to assist in research and development on problems associated with high voltage, high energy electrical discharges. Applicants should be at least 35 years of age and have a Higher School Certificate (Science) as a minimum qualification, possession of a Degree or Higher National Certificate in Electrical Engineering or Physics is desirable. A good basic understanding of electronics and practical experience of the generation of high voltage pulses and the measurement of very short time intervals would be an advantage. The salary scale is £982-£1,162 per annum (male). Application form from Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks. Quote Ref. 299/WGE/42. W 2618

UNIVERSITY OF EDINBURGH. Applications are invited for I.C.I. Research Fellowships in Biochemistry, Chemistry, Engineering, Pharmacology or Physics, to which some appointments will date from 1st October 1955 (or earlier in the case of selected candidates who may be available before that date). The salary will depend upon qualifications and experience, but will be within the range of £600 to £900 per annum, together with F.S.S.U. benefits and family allowances. Forms of application and further particulars may be obtained from the undersigned. Applications (two copies) should be submitted not later than 14th February 1955. Charles H. Stewart, Secretary to the University. W 1228

UNIVERSITY OF LONDON. Postgraduate Medical School. Assistant required in the Biophysics laboratories for development of instruments for medical research. Field covered includes electrocardiography, electrical and optical methods of following blood conditions, strain gauge methods of pressure recording, and other applications of electro-mechano transducers and recording devices for use on the human subject. The candidate should have had good basic training in the design and use of electronic circuits. The selected candidate will be a member of a small group, in well-equipped laboratories, with good workshop facilities, and must be capable of independent work under limited supervision and guidance. The age of candidates should be between 20 and 25. The salary will be that of a Senior Technician and will depend on age and on whether the candidate holds the Ordinary National Certificate in Electrical Engineering (or its equivalent). It will be not less than £460. Facilities are given for further study to the

level of the Higher National Certificate. Superannuation under the University of London Pension Scheme after six months' probation. Application forms from The Dean, Postgraduate Medical School, Ducane Road, W.12. W 2723

VACANCIES IN GOVERNMENT SERVICE. Draughtsmen required for electrical, electronic and mechanical work. Applicants with practical workshop experience and holding Ord. Nat. Cert. given preference, but those with design ability and practical workshop experience who are prepared to study for Ord. Nat. Cert. will be considered. Opportunities for permanent and pensionable posts. Apply to: Personnel Officer, G.C.H.Q. (Foreign Office), 53 Clarence Street, Cheltenham. W 1219

SITUATIONS VACANT

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 *inclusive or a woman aged* 18-59 *inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order,* 1952.

A. C. COSSOR LTD., Highbury, London, N.5, have vacancies for all engineering grades and Designer/Draughtsmen in their Research and Development Division 5. The programme of work includes Radio Communications, Television, Electronic Instruments, Primary and Secondary Ground and Airborne Radar, and Navigational Aids. In particular vacancies exist for Senior Engineers of good academic qualifications, and industrial experience; for recently qualified scientists and engineers with or without experience who wish to train for a career in the electronic industry; and for sen. Draughtsmen experienced in any of the above types of work. Salaries offered are consistent with present trends in the industry and the London cost of living: pension, welfare, and medical services are provided. Application in writing to the Personnel Manager, Mr. L. V. Cartwright. W 2561

A CANADIAN AIRCRAFT COMPANY urgently requires Aerodynamicists with University Degrees. Electronic Engineers with University Degrees. Experience in connexion with Aircraft desirable. Please reply immediately to Dept. 8, Ontario Department of Immigration, 12 New Burlington Street, London, W.1, for early interview. W 2732

A DRAUGHTSMAN, preferably under 30 years of age, with experience of light electro-mechanisms, instruments, or both, is required for a small team engaged in the design and manufacture of special-purpose apparatus. A sound background of workshop experience is essential. The appointment is at the Applicational Research Centre of a major Oil Company near Chester. Starting salary according to age and experience: attractive pension benefits. Write giving full details to Box ZO.100, Deacon's Advertising, 36 Leadenhall Street, London, E.C.3. W 2691

A LEADING FIRM OF RADIO and television manufacturers is establishing a team of mobile technical liaison officers and invites applications from well qualified and experienced field service engineers. The appointments are progressive, permanent and pensionable and afford unusual opportunities for men with thorough theoretical and practical knowledge of modern vision and sound receivers, including high fidelity reproducing equipment. Write, with full details of past career, to Box A.769 c/o Central News Ltd., 43 London Wall, E.C.2. W 2653

AN ELECTRONIC or Electrical Engineer, between the ages of 25 and 35 years, of Degree standard is required to take charge of the engineering department of a factory engaged in the manufacture of frequency control equipment. The successful applicant will be responsible for the design and specification of all new items as well as routine engineering problems. The position offers a wide scope for a person possessing the necessary technical qualifications and initiative to expand the work along numerous channels. Houses can be made available to successful applicants. Apply in writing to the Superintendent, Standard Telephones and Cables Ltd., Crystal Factory, Industrial Estate East, Harlow, Essex. W 2708

AN ENGINEER OR PHYSICIST is required for development work in methods of non-destructive testing and for the design, construction, and maintenance of instruments for use in research. Preference will be given to candidates with good experience in electronics. The post carries superannuation. Application should be made to "The Director of Research, Aluminium Laboratories Limited, Banbury, Oxon." W 2639

AN EXPANDING instrument firm pioneering new developments in the field of radiation physics has vacancies on its research staff for senior Electronic Engineers or Physicists with an electronic background. Applicants should have a sound theoretical training and considerable practical experience. The posts would be of particular interest to those who wish to obtain experience in new fields of electronic technology. The laboratory is pleasantly situated in Surrey and a Pension Scheme exists. Box No. W 2719.

AN OPPORTUNITY occurs in progressive manufacturing concern in London area for Engineer aged 25/35 with electrical or physicist degree, on development and research work on high frequency telecommunication cable and associated testing equipment. Salary will be commensurate with qualifications and experience. Apply giving full particulars to Box No. W 1163.

APPLICATIONS are invited for trainees as studio installation and maintenance engineers for home and overseas service with well-known television company. Apply Box No. W 2685.

APPLICATIONS ARE INVITED from engineers of inter B.Sc., or Higher National Certificate standard for investigational work on thermionic valves. Five-day week, staff pension scheme, modern welfare amenities. Apply, giving full particulars of age, qualifications, and experience to Personnel Superintendent, The Edison Swan Electric Co. Ltd., Cosmos Works, Brimsdown, Enfield, Middlesex. W 2617

APPLICATIONS ARE INVITED from Senior Planning Engineers, Tool Design Draughtsmen and Checker-Draughtsmen. Applicants should have served a sound engineering apprenticeship and have had experience of production planning, press tool, jig and fixture design in the light mechanical and electro-mechanical engineering fields. Men between the ages of 45 and 60 will be considered for the vacancies of checker-draughtsmen. These vacancies, which are caused by normal expansion of company business, offer attractive opportunities to keen and energetic men of good experience and qualifications who are capable of dealing with a varied class of work. Excellent commencing salaries will be paid to the selected candidates. Please reply, giving details of age, qualifications and experience to Box No. W 2627.

A PROGRESSIVE POST is available for an Aerial Designer (V.H.F.) in a large Group of Companies. Send details immediately of experience and salary required to Box W 2640.

ASSISTANT ENGINEER for Carrier Telephone Transmission work required by large engineering works in London area. H.N.C. or equivalent qualifications. Pensionable post carrying a salary commensurate with knowledge and experience. Box No. W 2662.

ASSISTANT ENGINEERS. 25-30 required for electronic and mechanical work near London. Good prospects of promotion, interesting work, and a pension scheme await suitably qualified graduates. Apply with full details of past experience to Box No. W 2599.

BELLING & LEE LTD. wish to engage a young graduate electronics engineer with experience of V.H.F. receiver layout and circuit design, the work being in connexion with the development of measurement apparatus for their television aerial laboratory, and communal broadcast and television amplifiers: British Nationality essential: contributory pension scheme. Applications (which will be treated in confidence) stating age, experience and salary required to the Secretary, Great Cambridge Road, Enfield, Middlesex. W 1218

BRITISH OVERSEAS AIRWAYS CORPORATION require a Radio Instructor in their Central Training Unit near London Airport. The successful candidate will be required for the A/c. Rad. Mtce. Engineers' Licences, Class A and B, and their radar ratings; also instruct Aircrew in the operation, and maintenance personnel in the maintenance and overhaul of current radio, radar and allied equipments; prepare technical manuals on the equipment. Qualifications—A.M.Br.I.R.E., A.M.I.E.E., C. & G. Final Certificate in Telecom, or equivalent. Experience in operation, maintenance and overhaul of aircraft rad., radar and electronic systems. Salary for this post will be from £725 p.a. to £912 10s. 0d. Applications should be addressed to Staff Superintendent, Recruitment, Building 29, London Airport, Hounslow, Middlesex. W 2649

BRUSH ELECTRICAL ENGINEERING CO. LTD., Loughborough, Leics, has vacancies for Research Engineers to assist with advanced projects connected with the development of new processes and materials for Rotating Electrical Machines. Men interested in Servo-Mechanisms, Computors, Ventilation, Insulation, Mechanical Design and associated technologies are invited to apply. Candidates should possess a good Degree in Electrical or Mechanical Engineering and have previous experience of Research or Development preferably on Electrical Machines. Conditions of service include non-contributory staff assurance scheme. Please reply with full details to the Chief Personnel Officer, Brush Electrical Engineering Co. Ltd., Loughborough, Leics. W 2726

BURNDEPT LIMITED have vacancies, due to expansion, for: 1. Telecommunications Development and research engineers. Qualified to operate as Project Leaders under direction of Chief Engineer on Government and proprietary designs. Experience must be within one or more of the following fields: (a) Aeronautical Telecommunications, both Airborne and Ground Station designs, with special emphasis on U.H.F. techniques within this field. (b) F.M. single and multi-channel equipment development in both V.H.F. and U.H.F. bands. (c) Development of subminiaturization techniques and special components. 2. Telecommunications Laboratory Instrument Mechanics and Wiremen. Must be fully conversant with modern miniature and subminiaturization techniques, and be able to wire from circuit diagrams on own initiative. Those capable of converting experimentally wired models to final stage by own initiative will receive special consideration. Excellent working and model shop facilities. Applications giving full particulars, including present salary, should be sent in confidence to Personnel Manager, Burndept Limited, Erith, Kent. W 2734

CHIEF OF TEST required by Elliott Bros. (London) Ltd. for a Division dealing with electronic instruments and magnetic amplifiers. Applicants should have had industrial experience, preferably in a test department, and have a good knowledge of pulse techniques, low frequency amplifiers and preferably have dealt with electronic industrial instruments and control equipment. Applications giving full details of age, qualifications and salary required to Personnel Officer, Century Works, Lewisham, S.E.13. W 2658

COMMUNICATION ENGINEERS and Draughtsmen. The expanding programme of the Transmission Department offers vacancies in both senior and junior categories for Line Transmission Laboratory Engineers, and Apparatus Design Engineers, and also for Draughtsmen with experience in telecommunications or light current engineering. Specialist experience in any branch of Line Transmission Engineering is desirable for some of the posts. Positions offered are on the Company staff with contributory Pension Fund and usual staff conditions. Applicants should write to Personnel Manager, Automatic Telephone and Electric Co. Ltd., Strowger Works, Edge Lane, Liverpool, 7, giving full details of age, qualifications, and experience. W 2602

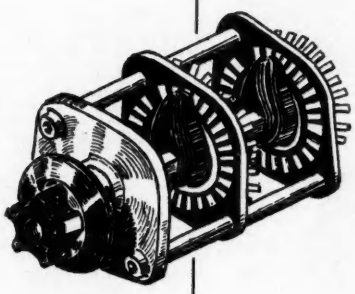
CLASSIFIED ANNOUNCEMENTS
continued on page 4

ELCOM

We are Tooled and in Production with

The "ELCOM"
BRITISH Designed & Produced
MULTI-BANK SWITCH

Incorporating . . .



30 positions per bank.

Adjustable stops with positive setting, up to maximum number of positions.

Single, double or three pole per bank.

Up to maximum of 6 banks in relation to other facilities.

OTHER PRODUCTS IN THE 'ELCOM' RANGE INCLUDE . . . .

STUDTYPE FADERS & ATTENUATORS
STUDTYPE ROTARY SWITCHES
MINIATURE VITREOUS & LACQUERED RESISTORS
MULTI-WAY PLUGS & SOCKETS

ELECTRONIC COMPONENTS

WEEDON RD. INDUSTRIAL ESTATE, NORTHAMPTON

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

CERAMIC CAPACITOR ENGINEER required South London area, age 26/35, to undertake design and technical supervision of manufacturing process. Technical education up to Inter-B.Sc. or Higher National Certificate standard in Telecommunication Engineering or equivalent. Industrial experience, preferably in radio, an advantage. Apply to Box No. W 1223.

DECCA RADAR LTD. require the following personnel. Senior Development Engineers capable of filing positions of responsibility for work on a wide variety of Radar projects. Applicants must have at least three years' experience of Radar development. Degree or equivalent qualifications an advantage. Senior Microwave Development Engineers. Degree or equivalent and at least three years' experience. For advanced design work on microwave aerials and components. Superannuation scheme and excellent opportunities for advancement in a rapidly expanding organization. Write full particulars to the Chief Development Engineer, Decca Radar Limited, Davis Road, Tolworth, Surrey. W 2677

DESIGNER DRAUGHTSMAN required for Electronics Division, Higher National Certificate or experience of Electronic Equipment an advantage. Progressive and permanent position. Pension scheme. Applications giving full details of qualifications and experience should be forwarded to Personnel Department (E.D.O.), Murphy Radio Limited, Welwyn Garden City. W 2721

DESIGNERS. Mechanical Designers with experience in small electro-mechanical and hydraulic mechanisms are required in Guided Weapons Division. Electronic Designers are also required with experience of practical layouts from circuit diagrams, and miniaturization and potting techniques. Applicants, aged 28-45, should have H.N.C., with workshop, and adequate drawing office experience. Applications quoting ref. No. 510 and giving details of age, education, training and experience, should be made to the Personnel Officer, Elliott Brothers (London) Ltd., Elstree Way, Borehamwood, Herts. W 2667

DEVELOPMENT ENGINEERS. Marconi's Wireless Telegraph Co. Ltd., Chelmsford, offer the following appointments to the permanent technical staff of the Company. These are well paid responsible positions suitable for applicants possessing design and development experience in the following fields: Ref. 2120, Aircraft Aerials. Experimental design and development of H.F. and V.H.F. Aerials Systems. Applicants should have had some experience in this field and preferably be familiar with small scale model techniques. Ref. 2130, Radio Links. Appointments are in connexion with the development of U.H.F. and S.H.F. Wideband Multichannel systems. Especially suitable for applicants with a knowledge of travelling wave tubes and centimetric techniques. Ref. 2140, Marine Communication and Radar. Appointments available in connexion with the development of marine transmitters, receivers, navigational aids and associated equipment. Ref. 2220, TV Equipment. Vacancies exist in connexion with the development of cameras, studio equipment, transmitters and associated apparatus. Ref. 2240, V.H.F. Mobile Equipment. Appointments available in connexion with the design of mobile transmitters, receivers and associated power supplies. All appointments are in connexion with the expansion of activities in the Company and carry excellent career prospects for applicants who are able to make an immediate contribution to the work of the Groups. Please write giving full details of qualifications and experience and quoting ref. SA.55 and appropriate reference number to Dept. C.P.S., 336/7, Strand, London, W.C.2. W 2624

DESIGN DRAUGHTSMAN. Leading Manufacturers require experienced man to take charge of small group responsible for complete engineering of Broadcast and Television Receivers. The post offers considerable scope with good prospects of advancement. Apply stating age, experience and salary required to The Personnel Manager, Box No. W 2562.

DEVELOPMENT ENGINEER required by leading firm of electrical component manufacturers in N.W. London for work in connexion with development of printed circuits and application to production. H.N.C. or Inter-B.Sc. standard. Experience of radio and T.V. technique essential. Superannuation scheme. Write stating age, full details of education, experience and salary required to Personnel Manager, Box No. W 1221.

DEVELOPMENT ENGINEER REQUIRED for work in conjunction with Magnetic Amplifiers as applied to Power Engineering. S.E. London factory. Shortly moving to Crawley, Sussex, where house will be available. Write stating full details to Hirst Electronic Development Ltd., Dermody Road, Lewisham, London, S.E.13. W 1231

DEVELOPMENT ENGINEERS required for design work in connexion with weighing and recording equipment combining electronic and electro-mechanical mechanisms. This is a new project offering plenty of scope for young men with initiative. Applications, giving personal particulars, should be addressed to Personnel Officer (Ref. EE/399). The British Tabulating Machine Co. Ltd., Letchworth, Herts. W 2665

DEVELOPMENT ENGINEERS for circuit design of radio and television receivers. Also Draughtsmen for radio and mechanical assemblies. Apply giving brief details to Raymond Electric Ltd., Brent Crescent, N.W.10. W 1233

DRAUGHTSMEN: Vacancies for senior draughtsmen with experience of Electronic and/or Electro-mechanical engineering required, preferably with experience of Ministry requirements. Excellent prospects with good commencing salaries; non-contributory Pension Scheme in operation. Applications will be treated in strict confidence and should give full chronological details of qualifications, experience and age to: John A. Smith Ltd., 24 Lichfield Street, Wolverhampton. W 201

DRAUGHTSMEN required for Detail Work and Wiring Diagrams to Ministry Specifications. Details of salary, age and experience to Peto Scott Ltd., Addlestone Road, Weybridge, Surrey. Weybridge 4271. W 2657

DRAWING OFFICE CHECKER required for Electronics Drawing Office. Several years' experience of Ministry procedure in connexion with Electronic Equipment essential. The post is permanent and pensionable and salary will be according to experience. Write giving full details of experience to Personnel Department, Murphy Radio Limited, Welwyn Garden City. W 2722

ELECTRICAL AND MECHANICAL ENGINEERS. Sunvic Controls Ltd. (a subsidiary of Metropolitan-Vickers Electrical Co. Ltd.) have the following vacancies in their new Development and Production Units at Harlow. 1. Graduate Engineer with experience in design or development of electro-mechanical mechanisms and their application to instrument problems. 2. Graduate engineer with practical experience in the development of electronic equipment and preferably a knowledge of the latest development in pulse techniques. 3. Application engineer of degree standard with experience in the application of electronic techniques to industrial and process control problems. The above positions are permanent and offer excellent prospects for promotion in a team engaged on the development and manufacture of a wide range of new instruments. Salaries will be according to age and ability. The Company's contributory pension scheme applies in all cases, and housing is available if required. Reply in writing, giving full particulars of age, experience, qualifications and present situation, to Chief Engineer, Sunvic Controls Ltd., Harlow, Essex. W 209

ELECTRIC LAMP DEVELOPMENT ENGINEER. Crompton Parkinson Limited have a vacancy in their Lamp Development and Research Laboratories at Guiseley for Experienced Lamp or Radio Valve Technician, capable of carrying out specific investigations and development work on electric discharge lamps, etc. The position vacant offers good salary rates, and good prospects of promotion. Preference given to graduate Physicist or Electrical Engineer. Superannuation Scheme. Write in confidence with full details to Reference LID, Crompton Parkinson Limited, Guiseley, near Leeds. W 1236

ELECTRONIC DEVELOPMENT ENGINEERS, Senior and Junior, with a leaning towards Technical Writing to undertake the preparation of Instruction Manuals, Specifications, etc., for Guided Weapons and like projects. A working knowledge of Pulse Circuitry and Microwave Techniques essential. Apply, giving full details of experience, age, etc., to the Personnel Manager, The General Electric Co. Limited, Brown's Lane, Allesley, Coventry. W 2664

ELECTRONIC COMPUTING techniques are now being successfully applied to many accounting and statistical problems. There are excellent prospects with the expanding Production Development and Research Departments of the British Tabulating Machine Co. Ltd., Letchworth, Herts, for University Graduates and men of H.N.C. standard or higher with an interest in electronics and their application to computing machines. The Company will be pleased to hear from men seeking an opening in this field. Assistance with housing may be given to suitable applicants. Pension and Sick Pay Schemes are in operation. Enquiries should be addressed in the first instance to Personnel Officer. W 2684

ELECTRONIC DIGITAL COMPUTORS. E.M.I. Engineering Development Ltd., require Engineers and experienced programmers for the development of automatic data processing equipment. The project requires development of circuit and electro magnetic devices; and the investigation of information storage methods. An interest in commercial work is essential. The posts are permanent and pensionable and offer attractive prospects in a new and expanding field. Applicants should write with full details to Personnel Dept. (ED/219), E.M.I. Eng. Dev. Ltd., Hayes, Middx. W 2738

ELECTRONIC ENGINEER required in the Electronics Section for a large food organisation in N.W. London, for the construction and maintenance of specialized factory equipment. Applicants should possess initiative and be between the ages of 20-30. Salary according to age and experience. Write Box E.E.635, c/o 191 Gresham House, E.C.2. W 2730

ELECTRONIC ENGINEER required for Engineering Factory in Yorkshire. Applicant should be experienced in design and application of High Frequency for Heat Treatment, etc. Write giving age, experience, and salary required to Box No. W 2623.

ELECTRONIC ENGINEER Development Engineer required by a progressive engineering company situated in the London area. Applicants, who should possess a good engineering Degree, should have practical experience in design and development of V.H.F. electronic equipment. Please reply, in confidence, giving full details to Box No. W 2659.

ELECTRONIC ENGINEER for research and development post with well-known Birmingham Company. Applicants should possess University Degree and have had experience in pulse techniques and digital computor principles. The appointment offers good prospects and conditions in a substantial organisation. Pension scheme. Apply stating age and qualifications to Box No. W 2713.

ELECTRONIC ENGINEERS are required for work on advanced valve applications—minimum qualifications H.N.C. or B.Sc. and previous experience. TA/G. Personnel Dept., M.O. Valve Co., Brook Green, Hammersmith. W 2661

CLASSIFIED ANNOUNCEMENTS
continued on page 6

EKCO

Electronic scaling equipment

AUTOMATIC SCALER TYPE N530

This new Type N530 Automatic Scaler times a pre-determined count or counts for a pre-determined time, it can also be manually operated. It incorporates a stabilised high voltage supply for polarising a Geiger-Muller Probe or Scintillation Counter, an input amplifier and a pulse height discriminator. With the addition of a suitable radiation counter it forms a complete counting or timing equipment.

SCALER TYPE N529

Ekco Type N529 is a five decade Scaler using 'Dekatron' tubes. Like the N530 it incorporates a stabilised high-voltage supply, an input amplifier and a pulse height discriminator, and it requires only the addition of a suitable radiation counter to form a complete counting equipment. The setting-up controls are situated behind a hinged door and routine operation is by means of press-button switches.

Write for the complete catalogue of Ekco Nucleonic and Electronic Equipment, including Scintillation Counters, Scaling Units, Counting Ratemeters, Radiation Monitors, Vibrating Reed Electrometers, Geiger-Muller Tubes, Lead Shielding, Linear Amplifiers, Power Units, Complete Counting Installations, Thickness Gauges.

EKCO electronics

Sales, Service and Installation

EKCO ELECTRONICS LTD. EKCO WORKS SOUTHEND-ON-SEA ESSEX

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

ELECTRONIC ENGINEER required by Company in East Anglia to take charge of small but expanding department wiring and testing electronic units for precision instruments; practical production experience essential; pension scheme. Details of age, experience and salary required to Box No. W 1235.

ELECTRONIC ENGINEER with practical experience in industrial applications and good technical knowledge is required by a large food organization centred in London for the development, design and construction of electronic equipment. Applicants should have initiative and be resourceful. Post will be of supervisory grade and salary according to age and experience. Apply Box No. W 2733.

ELECTRONIC ENGINEERS. Mullard Equipment Limited have four vacancies in their Development Laboratories in S.W. London for electronic engineers to work on VHF Radio Transmitters and Receivers, Meteorological Radar Equipment. A Degree is preferable but men with H.N.C. or C. & G. full Technological Certificate are also eligible. A minimum of two to three years' industrial experience essential. Starting salary will be between £600 and £700 according to age and experience. These appointments offer careers to suitable applicants. The Company has a progressive salary policy, contributory Pension Scheme, canteen facilities, etc. Applications should be sent to: Personnel Officer, Mullard Equipment Limited, 51/55, Garratt Lane, Wandsworth, S.W.18. W 2676

ELECTRONIC ENGINEERS required. Excellent opportunity for men of Degree standard to broaden experience in a field of great interest and variety and involving latest techniques. Restrictive specialization can be avoided by joining Marconi Instruments who produce light current communication, measuring and test apparatus for a wide range of requirements. Apply Marconi Instruments Ltd., Longacres, Hatfield Road, St. Albans. W 2680

ELECTRONIC ENGINEERS with several years' research or development experience are invited to apply for posts with a well established Company engaged primarily on the development of precision electronic laboratory instruments. Applicants should preferably possess a Degree or equivalent qualifications in physics or light electrical engineering, although this is not essential as considerable practical experience is equally acceptable. The appointments are of a permanent nature for Engineers able to undertake the responsibility for the development of new projects to the prototype stage, and they offer scope for the exercise of individual initiative. Furthermore, the work covers a wide range of electronic instruments and similar devices. Salaries are commensurate with qualifications and experience. Applications should be made in writing, stating full details, to Personnel Manager, Furzehill Laboratories Ltd., Boreham Wood, Herts. W 2697

ELECTRONICS ENGINEER for production required by Unicam Instruments Ltd., Arbury Works, Cambridge, for spectrophotometer department. Several years' electronic experience essential. The post would suit a Service Trained Electronics Engineer shortly to complete his engagement or someone with comparable experience. Write in the first instance to Personnel Manager, giving age, full details of education and previous experience. W 2650

ELECTRONICS ENGINEER required by Middlesex firm of manufacturing chemists. Applicant should be qualified mechanical or electrical engineer with experience of factory engineering allied to electronic controls. Post offers excellent opportunity to men with progressive outlook. Write giving fullest details of age, qualifications, experience and salary required to Box No. W 2683.

ELECTRONICS ENGINEERS. Vacancies exist in the expanding Electronics Division of Saunders-Roe Limited. The range of work is unusually wide and interesting, covering design and development of analogue and digital computors, electro-mechanisms, measuring apparatus, strain gauging equipment and techniques, etc. Salaries offered are commensurate with qualifications and experience. Assistance will be given with accommodation. Write stating age, experience, etc., or send P.C. for application form to the Personnel Department (Ref. EE/17), Saunders-Roe Limited, East Cowes, I.O.W. W 2709

E.M.I. Domestic Electronics Division have a vacancy for a T.V. design engineer for an interesting programme in receiver development (including colour receivers). Applicants should have good academic background with at least three years' experience in this field. Please write with full details to Personnel Dept. (DED/2), E.M.I. Factories Ltd., Blyth Road, Hayes, Middlesex. W 2636

E.M.I. ENGINEERING DEVELOPMENT LTD., have a vacancy for a Mathematician or Mathematical Physicist—preferably an Honours Degree to study and assess weapon performance. The problems require original thought and a critical approach to the data available. A knowledge of electronics would be useful but not essential. Applicants should write in confidence with full details to Personnel Dept. (ED/205), E.M.I. Eng. Dev. Ltd., Hayes, Middx. W 2724

E.M.I. Domestic Electronics Division have a vacancy for a development engineer in their component laboratory, for work which includes design of high fidelity equipment, loud speakers and pick-ups. Applicants should have a good academic training and preferably experience in the design of electro-mechanical components. Please write with full details to Personnel Dept. (DED/3), E.M.I. Factories Ltd., Blyth Road, Hayes, Middlesex. W 2637

ENGINEER, aged 25 to 35, preferably having Higher National Certificate, required for the maintenance of electronic equipment and the testing and alignment of new instruments used for quality control and automatic testing of all types of telecommunication cables. Apply giving full particulars to Box No. W 1187.

ENGINEER fully experienced in radio and television design and development, required to assist Chief Development Engineer of leading London electrical component manufacturers in development of printed circuits. Qualifications at least to A.M.I.E.E. standard. This position offers scope for the right man who must be capable of initiating and following projects to finality including contacts with customers. Superannuation scheme. Write giving full details of qualifications and experience, age and salary required to Personnel Manager, Box 3M.L 9241, A.K. Advg., 212a, Shaftesbury Avenue, London, W.C.2. W 2655

ENGINEER OR PHYSICIST required by large Company of world-wide renown in Birmingham. Applicants should be well qualified academically and have experience in experimental physics or instrumentation. The appointment offers good prospects and conditions in a substantial organisation. Pension scheme. Apply, giving details of age and qualifications to Box No. W 2712.

ENGINEER OR PHYSICIST required for development and operation of a high voltage machine for nuclear research. Experience of large-scale electrical equipment and electronic engineering desirable. Initial salary in the range £600-£900 per annum. Applications as soon as possible to Professor S. Devons, Imperial College, South Kensington, S.W.7. W 2706

ENGINEERS required for installation and operation of television transmission equipment. Apply in first instance by letter to Engineer-in-Charge, Pye Ltd., 11 Hinde Street, London, W.1. W 2686

ENGINEERS (RADIO VALVES) are required for all grades of work on development, production and pre-production—minimum qualifications H.N.C. or B.Sc. for Senior positions—O.N.C. or Inter for Junior—some experience necessary for Senior appointments. TA/4 Personnel Dept., M.O. Valve Co., Brook Green, Hammersmith, W 2660

ENGINEERS, TECHNICAL ASSISTANTS are required at all grades for work on valve development, valve pre-production and electronic engineering. Minimum qualifications, H.N.C. or B.Sc. for Senior positions and O.N.C. or inter for Junior. Whenever possible company offers promotion from within and salaries reviewed regularly. Write: Personnel Officer, The M.O. Valve Co. Ltd., Brook Green, Hammersmith, London, W.6. W 1151

ENGLISH ELECTRIC VALVE CO. LTD., Chelmsford, have vacancies for Young Engineers to work on radio valve design and development. Applicants should be of Degree standard. Whilst experience of this type of work is desirable, it is not essential and otherwise suitable candidates will be considered. Write giving full details quoting Ref. 497L, to Dept. C.P.S., 336/7 Strand, W.C.2. W 2731

ERICSSON TELEPHONES LTD. have in their Research Laboratories a number of vacancies for circuit designers and equipment engineers to work on nucleonic instruments, and interesting new developments in electronic computing and switching; both senior and junior posts are available. Applicants should have a degree or equivalent plus several years' experience of appropriate work for the senior posts; correspondingly reduced qualifications and experience will be accepted for junior posts. Salaries will be in accordance with age, qualifications and experience. Applications, giving details of age, academic or other training and qualifications, experience, and starting salary required, should be sent to the Personnel Officer, Ericsson Telephones Ltd., Beeston, Nottingham. W 197

ESTIMATING ENGINEER with knowledge of electronic applications and circuitry required for Electronics Division of Transformer Sales Office. Staff Pension scheme and active Social Club amenities. Write giving full details of experience to Manager, Sales Office, Gresham Transformers Limited, Twickenham Road, Hanworth, Middlesex. W 2651

ESTIMATING ENGINEER required with experience of estimating of machine and assembly work in connexion with the light electro-mechanical engineering industry. Coiling experience desirable but not essential. An attractive salary will be offered to the selected candidate. East London area. Please write, giving full details of qualifications and experience, to Box No. W 2629.

EXPANDING COMPANY engaged on Electronic Engineering requires the services of a Chief Planning Engineer in charge of Process Planning and Tool Design. University graduate preferred, but ability and experience regarded of greatest importance. Within radius of 30 miles of London. Permanent pensionable position, with a commencing salary of £900-£1,200 p.a. Apply Box No. W 2632.

EXPERIENCED Radio Testers and Inspectors required for production of communication and radio apparatus. Also Instrument makers, wirer and assemblers for Factory Test apparatus. Apply Personnel Manager, E. K. Cole Ltd., Ekco Works, Malmesbury, Wilts. W 146

EXPERIENCED ENGINEERS required for design of electronic instruments for Aircraft, Marine and Industrial applications. Salary £600 to £1,000. Housing assistance. Apply: Simmonds Aerocessories Ltd., Treforest, Pontypridd, Glamorgan, S. Wales. W 2678

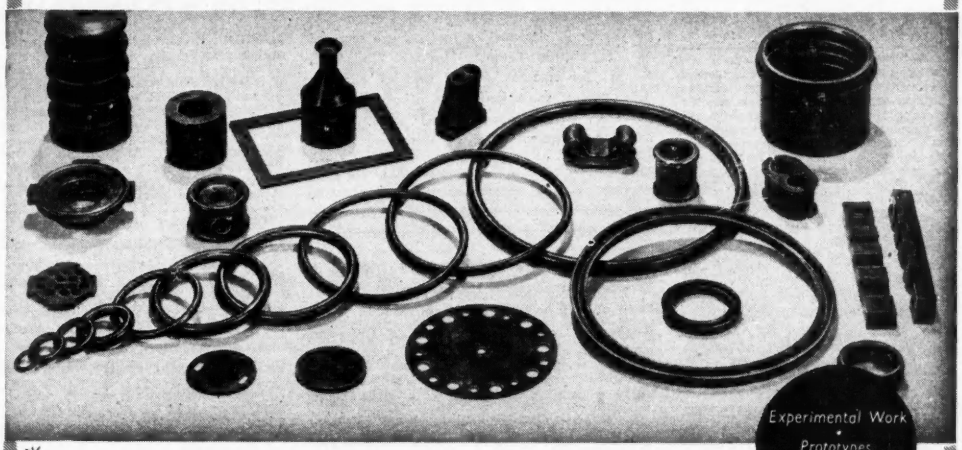
EXPERIENCED FAULT-FINDERS wanted by Midland Manufacturers of Radio Equipment. Permanent posts located in the Midlands are offered to men with experience of Radar, Radio Control, V.H.F. Equipment. Write stating fully experience and salary required to the Personnel Manager, Box No. 2669.

EXPERIENCED TECHNICAL executive required by successful Public Television & Radio Company, to supervise National organisation for development, manufacture and service. Opportunity of Directorship for right man. Pension. Full details in strict confidence to Box W 2634.

FERGUSON RADIO CORPN. LTD., have vacancies for—Senior Engineers with initiative and sound technical background for work on a

CLASSIFIED ANNOUNCEMENTS
continued on page 8

*PRECISION RUBBERS LTD.



Experimental Work • Prototypes • Bulk Production

***Specialists in Rubber and Synthetic Rubber Mouldings for Industry**

Manufacturers of Rubber Parts for ROLLS-ROYCE LTD

SEALS · BONDED PARTS · CORD RINGS · DIAPHRAGMS · SILICONE RUBBER COMPONENTS

PRECISION RUBBERS LTD · BAGWORTH · LEICESTERSHIRE · Phone: BAGWORTH 241/2

Rola Celestion

The Final Word

In all radio reproduction it is the LOUDSPEAKER which has the Final Word. It is the LOUDSPEAKER which finally determines the quality of reproduction.

The finest radio receiver in the world can only give indifferent results if fitted with an indifferent LOUDSPEAKER.

It is the LOUDSPEAKER which re-creates the sound and it is the LOUDSPEAKER above all which must be BEYOND REPROACH.

We have loudspeakers for every purpose and set manufacturers are invited to collaborate with us on all problems relating to sound reproduction.

Model P44
Lightweight 12" Loudspeaker

Rola Celestion Ltd. FERRY WORKS, THAMES DITTON, SURREY

Telephone: Emberbrook 3402-6

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

wide range of projects in the field of Electronics including Television, Radio, Communications and Test Equipment. Permanent posts for men able to carry responsibility in rapidly expanding department offering exceptional promotion and long-term prospects. Junior Engineers of ability to work on Development projects offering a wide experience in the fields of Television, Radio, Communications and Test Equipment with excellent prospects for advancement. Vacancies exist in Laboratories situated both at Enfield and Spennymoor, Co. Durham. These Laboratories are well equipped and working conditions excellent. Successful applicants eligible for Company's Pension and Life Assurance Scheme. Applications specifying the post for which application is made and giving full particulars as to age, qualifications and experience, etc., to: Personnel Manager, Ferguson Radio Corpn. Ltd., Gt. Cambridge Road, Enfield. W 2652

FERRANTI ELECTRONIC COMPUTORS. Ferranti Ltd. (Computor Dept.), Moston, Manchester, have the following vacancies. (1) Senior Engineers for Research and Development work on large-scale electronic computing equipment. Qualifications: First- or good second-class Honours Degree in electrical engineering with previous experience of development work in electronics or with electrochemical devices. Ref. D.C.S.E. (2) Engineers for the commissioning section and for maintenance of computing equipment. Qualifications: For senior posts a Degree in electrical engineering and for the more junior approximately H.N.C. standard but more essentially experience with electronic circuitry and test equipment. Ref. D.C.M.F. Permanent Staff appointments with Pension Benefits. Application forms from Mr. T. J. Lunt, Staff Manager, Ferranti Ltd., Hollinwood, Lancs. Please quote appropriate reference. W 2578

FERRANTI LIMITED, EDINBURGH—Flight Trials Division. Applications are invited for Electronic Engineer for interesting work in their Flight Trials Division. The engineer will be engaged on trials to evaluate the technical and operational performance of fire control and navigational systems, air and ground. The qualifications required are to degree or equivalent standard with a minimum of three years' experience. Ref. No. EE/TID. Radar Maintenance Engineer who will be responsible for a small outstation. Duties will involve limited travelling in the U.K. Ref. No. RME/TID. Ex-Radar Officers and Senior N.C.O.s are invited to apply for either or both vacancies. The appointments are pensionable and offer excellent prospects and working conditions in or attached to our new laboratories. Apply for an application form, quoting appropriate reference number, to the Personnel Officer, Ferranti Limited, Ferry Road, Edinburgh, 5. W 2679

FERRANTI LTD. have vacancies for Junior and Senior Design Draughtsmen for their London Computer Laboratory. Successful candidates would be concerned with interesting electro-mechanical design and circuit work, offering scope for using initiative and for advancement in the rapidly expanding field of Information Handling. Candidates should be between 25 and 35 years of age and possess O.N.C. or H.N.C. or equivalents and should have had workshop training and experience with electronic equipment, instruments, and precision mechanisms. The Company operates a Staff Pension Scheme. Application forms from Mr. T. J. Lunt, Staff Manager, Ferranti Ltd., Hollinwood, Lancs. Reference WSE/3. W 2702

GRADUATES with Honours Degrees in Physics or in electrical engineering are required by the British Thomson-Houston Co. Ltd., Rugby, for research in the field of Klystron development; some knowledge of electronics is desirable. Applicants should write to the Director of Research, giving their age, qualifications and College, quoting the reference DR. W 2592

GRADUATES WITH HONOURS Degrees in Physics or in Electrical Engineering are required by the British Thomson-Houston Co., Ltd., Rugby, for research in the field of Thyratron development; some knowledge of electronics is desirable. Applicants should write to the Director of Research, giving their age, qualifications and College, quoting the reference K.B. W 2591

HIGHER NATIONAL CERTIFICATE in Electrical Engineering. Vactric Ltd., wish to interview applicants with above qualifications for position as Development Engineer for high frequency miniature electric motor projects. Write Personnel Manager, Electric Motor Division, 19 Brunel Road, Acton, W.3. W 1240

HONOURS GRADUATES in Physics or Electrical Engineering are required for advanced work in a Quartz Crystal Laboratory. The positions offered afford excellent opportunities for young men to specialize in the study of piezoelectric materials, from both the theoretical and practical viewpoints. An interest in mathematics and electronics would be an advantage for this work. Houses can be made available to successful applicants. Apply in writing to the Superintendent, Standard Telephones and Cables Ltd., Crystal Division, Industrial Estate East, Harlow, Essex. W 2707

IMPORTANT ELECTRICAL manufacturers of High Frequency and other electronic equipment require first-class service engineer for Midland areas. Preference given to candidates with experience of electrical maintenance or radio transmission. Education should be to National Certificate standard. Excellent prospects. Pension Scheme. Write stating full details of education, experience, present position and salary required to Box No. W 2693.

INSTRUMENT LABORATORY PERSONNEL. Vacancies exist in the Instrument Laboratory of an expanding organization dealing with Guided Missiles, Navigational Systems, Magnetic Amplifiers, Transformers, Miniature Motors, etc. Applicants should possess H.N.C. or equivalent and have some practical experience in this or an allied field. Positions are permanent and attractive; assistance can be given with housing and removal. Applications with full particulars to—Staff Appointments Officer, Short Brothers & Harland Limited, P.O. Box No. 241, Belfast, quoting S.A.22. W 2706

JUNIOR DESIGNERS required to deal with small transformers, power, audio, pulse, etc. Specialized training will be given to engineers with suitable basic training and experience. Applications to Technical Director, Gresham Transformers Ltd., Twickenham Road, Hanworth, Middlesex. W 1158

JUNIOR DEVELOPMENT ENGINEERS are urgently required to assist in the development of precision electronic laboratory instruments. Successful applicants will be engaged on interesting long-term projects concerned with the development of a wide range of equipment. The appointments are permanent and carry considerable technical responsibility. Applicants should have had previous development experience preferably in the instrument field. Academic qualifications ranging from H.N.C. to Degree standard are preferable. Salaries are dependent upon age, qualifications and experience. Apply stating full details to the Personnel Manager, Furzehill Laboratories Ltd., Boreham Wood, Herts. W 2695

JUNIOR ENGINEER for interesting design and development work on Electronic and Vibration Test equipment. Applicants should have O.N.C. or equivalent, a sound knowledge of Industrial Electronics, be capable of wiring prototype equipment to approved standards, and working on own initiative if required to do so. Good welfare facilities including staff pension scheme. Applications in writing to Personnel Manager, Hunting Percival Aircraft Limited, Luton Airport, Beds., stating age, experience and salary required. W 1225

LIAISON ENGINEER/WRITER required with sound basic knowledge of television and radar principles. He will be required to work with design teams engaged on complex television and radar projects, to assimilate the technical details and subsequently prepare technical notes in good and concise English. Applicants should write, with full details to the Personnel Dept. (ED/182), E.M.I. Eng. Dev. Ltd., Hayes, Middx. W 2725

JUNIOR OR INTERMEDIATE ENGINEERS for Vibration Section. Applicants should have had some experience with mechanical vibration problems, and the application of electronic and similar methods of measurement generally. Experience of oscillograph record analysis would be an additional advantage. Applicants should be at least up to Degree standard, but direct experience will be set against academic qualifications. Salary in accordance with experience and qualifications. Staff Pension Scheme and excellent working conditions. Applications giving details of experience, qualifications and salary required, quoting E.D.17, should be addressed to the Personnel Manager, The Bristol Aeroplane Company Limited, Engine Division, Filton House, Bristol. W 2643

MARCONI INSTRUMENTS LTD. have an immediate vacancy at St. Albans in their Technical Literature (Telecommunications) Section. The applicants should have electrical engineering qualifications and/or experience in the design or development of electronic equipment. The duties are varied and interesting and the post provides a permanent and pensionable position in a well established Company. Apply Marconi Instruments Ltd., Longacres, Hatfield Road, St. Albans. W 2681

METHODS DEVELOPMENT SECTION of Pye Limited has vacancies for Senior and Junior Television circuitry Engineers and Mechanical Development Engineers to work on Printed Circuit and other new system developments. This is work in a new and expanding field and offers almost unlimited scope for Engineers with drive and initiative. Salaries dependent on qualifications and experience. Apply to Chief Television Engineer, Pye Ltd., Cambridge. W 2737

McMICHAEL RADIO LTD., Slough, Bucks, have vacancies from time to time for Electronic Engineers to be engaged on Government projects. Those wishing to be considered are invited to write fully to the Chief Engineer, Equipment Division. W 205

METROPOLITAN-VICKERS ELECTRICAL CO. LTD., Trafford Park, Manchester 17, have vacancies for servo engineers with some practical experience in Electric servo and control circuit design and application. Qualifications required, a Degree or Higher National Certificate. Applicants should not be less than 26 years of age. The posts are permanent and pensionable. Salary according to qualifications and experience. Apply in writing to The Personnel Manager, marking envelope "Servo Mechanisms." W 2557

MULLARD LIMITED require a Sales Engineer for their Equipment Division. Candidates should have previous industrial experience, pre-

CLASSIFIED ANNOUNCEMENTS
continued on page 9

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

ferably in the application of oscilloscopes or other electronic test instruments. Permanent and pensionable appointment. Write giving age, and full details of education, training, previous experience and salary required to the Personnel Officer, Mullard Limited, Century House, Shaftesbury Avenue, W.C.2. W 2635

MULLARD RESEARCH LABORATORIES. Vacuum Physics Laboratory. Colour Television. Applications are invited from both senior and junior graduate Physicists who are interested in colour television research. The work is primarily concerned with the final picture-formation stage: it thus includes studies of the fundamental problems involved in the creation by electronic means of animated colour images, and is expected to lead to the development of new types of display devices. Candidates capable of contributing to original research will not be excluded by reason of lack of experience in the television field. Immediate interviews will be arranged for suitable applicants. Attractive conditions of employment at good salary levels are available to those finally selected. Apply, quoting reference V.P.L., to: Mr. G. A. Taylor, Personnel Manager, Mullard Research Laboratories, Cross Oak Lane, Salfords, Near Redhill, Surrey. W 2625

MUIRHEAD & CO. LTD., Beckenham, Kent, have vacancies for: Physicist or Electrical Engineer (qualified) for development work on data transmission devices, miniature motors and instrument servo-mechanisms. Laboratory experience in light electrical engineering desirable. Technical Assistant for interesting experimental work in laboratory dealing with electro-mechanical devices and electronics. Young man having completed his National Service and holding O.N.C. or H.N.C. (Elect.) is desired. First-class working conditions with modern canteen. Pension Scheme. Apply by letter stating details of age and experience to Personnel Manager. W 2682

NELSON RESEARCH LABORATORIES, Stafford, have vacancies for Senior and Junior Engineers for interesting research and development work on Servo and Electromechanical Systems. The work includes both experimental and analytical approach with the aid of calculating machines, where necessary. Junior engineers who have Honours Degrees and have completed engineering apprenticeships will be given training in this work if required. Apply to Dept. C.P.S., 336/7, Strand, W.C.2., quoting Ref. 1327B. W 2675

NELSON RESEARCH LABORATORIES, Stafford, have a vacancy in their Electronic Test Section for an experienced man for initial inspection and testing of electronic equipment. Practical experience in the maintenance of electronic, electrical control and recording equipments an advantage. Preference will be given to people who hold a City and Guilds final Telecommunications Certificate. Please write full details to Dept. C.P.S., 336/7, Strand, W.C.2, quoting Ref. No. 944C. W 2688

NELSON RESEARCH LABORATORIES, Stafford, have a vacancy for an experimental graduate Physicist for interesting work on semi-conducting materials. Experience in this field is desirable but not essential. Reply stating age, qualifications and experience to Dept. C.P.S., 336/7, Strand, W.C.2, quoting Ref. 312. W 2700

PATENTS ASSISTANT. Ferranti Ltd., Hollinwood, Lancs., have a vacancy for a technical assistant in their Patents Dept. Previous experience of patent work is not necessary but particular interest in and aptitude for it is essential as the successful candidate would be expected to qualify as a Patent Agent in due course. Applicants should have a Degree in Electrical Engineering or Physics with special emphasis on electronics, and should preferably be between 25 and 30 years of age. Permanent staff appointment with pension benefits. Application forms from Mr. T. J. Lunt, Staff Manager, Ferranti Ltd., Hollinwood, Lancs. Please quote Reference PD. W 2633

PROJECT ENGINEERS are required to take charge of microwave electronic and mechanical developments in connection with guided weapon and other applications in a company near London. Candidates should be graduates between the ages of 30 and 40. Salaries range from £1,000 upwards according to age and experience. Pension scheme in operation. Full particulars, which will be treated in confidence, should be addressed to Box No. W 2601.

PHYSICIST OR CHEMICAL ENGINEER, graduate or equivalent training, required for research and development on vacuum drying and allied problems. Must have laboratory experience, preferably in the vacuum and/or refrigerating fields. Permanent pensionable position with commencing salary according to age and experience and commensurate with the first-class man sought. Housing available. Applications with full details to Personnel Officer, W. Edwards & Co. (London) Limited, Manor Royal, Crawley, Sussex. W 2716

PHYSICISTS. A vacancy is available for a Physicist holding a Ph.D. Degree, and having practical experience, for work on the production of power from atomic energy, and to be emp'oyed initially at Harwell, age 30-35. A vacancy is also available for an Assistant to the above, age 26-30. Good salaries will be paid to men holding the necessary qualifications. Box No. W 1205.

RADIO AND T.V. Engineer required by Mains Radio Gramophones Ltd., to take over position of Chief of Test. To be responsible for test standards and for technical liaison between development and production. Good prospects in expanding organisation for right applicant. Superannuated staff position. Please send details of experience and salary expected to the Personnel Manager, 359 Manchester Road, Bradford. W 1239

REGENTONE RADIO & TELEVISION LTD. have the following vacancies: (a) Senior Engineer to take control of section engaged on research and development of television receivers. Candidates with initiative, sound technical background, and experience in this field, will be expected to initiate desigs and carry them through to production stage. Salary up to £1,000 p.a. commensurate with ability. (b) Development Engineers for work in connexion with television and radio receiver design. Candidates must have good technical background and at least five years' laboratory experience. (c) Junior Development Engineers to assist in development of television, radio and components. Must be educated to at least Higher National Certificate or equivalent, with preferably some laboratory experience. (d) Test Gear Engineers with sound experience of the design and manufacture of special equipments required for the testing of mass-produced radio and television receivers. Sound technical knowledge and ability to carry design through to finality. (e) Experienced wiremen/testers for section engaged on production of specialized equipment designed for mass production testing of te'evision and radio receivers. Experience of this or similar work essential. (f) Production Development Engineers with sound experience of engineering laboratory designs for mass production manufacture. Candidates must have good technical background and have practical outlook with considerable mechanical experience. Excellent prospects are open to successful candidates, with good salaries, staff status and participation in company's superannuation and life assurance scheme. The laboratories are well equipped and modern in design and afford excellent working conditions. Apply at first in writing, giving full details of experience, technical training, salary and all relevant details to: Personnel Manager, Regentone Radio & Television Ltd., Eastern Avenue West, Romford, Essex. W 2621

RADIO AND RADAR TESTERS. First-class men required for work on V.H.F. Communication Gear and Government Contracts for Radio and Radar Equipment by Midland Manufacturers. Men with wide experience of Fault Finding in any of the fields mentioned should write giving full details to Box No. W 2668.

RADIO AND T.V. ENGINEER with laboratory experience required by leading London firm of electrical component manufacturers for work in connexion with printed circuits. H.N.C. standard. Superannuation scheme. Write giving full details of education and experience, age and salary required to Personnel Manager, Box 3ML 9247, A.K. Advg., 212a, Shaftesbury Avenue, London, W.C.2. W 2656

RESEARCH. A Senior Engineer is required by a well-known established Instrument Manufacturer in the London area. Knowledge of Supersonic Flaw Detector techniques at an advanced level is essential, whilst a good production engineering and/or mechanical design experience would be a most useful asset. The post is pensionable and offers scope to an Engineer with initiative combined with the right background. An initial salary will be paid commensurate with experience within the £1,000-1,500 p.a. range. Applications may be made in the strictest confidence and should give details of experience, academic qualifications, age and salary required, and be addressed to Box No. W 2644.

RESEARCH ENGINEERS, preferably of Degree standard and with a sound knowledge of communications and particularly electronics, required for experimental work relating to underwater sound apparatus. Applications, giving past experience, technical qualifications, age and salary required, should be addressed to the Personnel Manager, Kelvin & Hughes Ltd., New North Road, Barkingside, Ilford, Essex. W 2645

SCIENCE GRADUATES in physics or chemistry (male or female) who wish to make a career in the electrical and electro-chemical field are invited to apply for vacancies which occur in a new and well equipped modern laboratory. Candidates should be in the 23-28 age group, keen, not afraid of work and prepared to take the responsibility of supervising projects into production. Opportunities for promotion to Section Leader in a development Team would arise from these positions. Attractive salaries are payable for these posts and the company operates a Pension Scheme. Replies in confidence, quoting E.C.1, to Box No. W 2641.

SENIOR AND JUNIOR Development Engineers required for responsible work in Radio and Television Development Laboratories. Applicants for senior position should be able to undertake development work with minimum supervision. Excellent conditions and salary available for applicants who are accepted. Apply in first case to Personnel Manager (Dept. R.D.), McMichael Radio Ltd., Wexham Road, Slough, Bucks. W 2671

SENIOR DEVELOPMENT ENGINEERS. Vacancies exist in the Outer London area for Senior Development Engineers to work on the study, development and engineering of prototype electronic equipment, involving considerable mechanical appliances on digital computing, measuring equipment, atomic control and G.W .operational equipment. These posts are pensionable and offer considerable future prospects. Salary £800 to £1,200 per annum according to qualifications and experience Please reply, giving full details, to Box No. W 2626.

SENIOR ASSISTANT to take charge of small electronics section of laboratory. The work involves acoustics, vibration, use of strain gauges and the development of special equipment for research and development work on steam and gas turbines, gears, pumps, alternators, etc. Sound theoretical training to

CLASSIFIED ANNOUNCEMENTS
continued on page 10

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

H.N.C. or Degree desirable. Practical ability essential. Experience in engineering an advantage. Staff Pension Scheme. Apply stating qualifications, age, experience and salary required to the Secretary, W. H. Allen Sons & Co. Ltd., Queens Engineering Works, Bedford. W 2690

SENIOR ELECTRONIC ENGINEER required by Radio Component Manufacturers (London area) to take charge of test equipment development and maintenance. Would also be appointed Chief Inspector (AID). Write fullest particulars of qualifications, experience and present salary. Box No. W 1232.

SENIOR ELECTRONIC ENGINEERS, Mechanical Designers, Draughtsmen and Detail Draughtsmen are required by a Leading Midlands Manufacturing concern engaged on the design, development and production of domestic Radio and Television and on Government Contract Work. An expanding programme will provide excellent opportunities for promotion. Applicants should write to The Personnel Manager (Ref.GLB.), Box No. W 2720.

SENIOR ENGINEER required for small expanding company. Knowledge of microwave technique essential. Ph.D. or Honours Degree preferred. Salary commensurate with ability. Details to Microwave Instruments Limited, West Chirton Industrial Estate, North Shields, Northumberland. W 2638

SENIOR ENGINEERS required for research and development work on magnetic amplifiers, transistors and electronics, with particular reference to aircraft and guided weapon applications. Only engineers whose experience commands a salary of £600 p.a. and upwards need apply. Full particulars to Box No. W 1230.

SENIOR ESTIMATORS required by a large and progressive engineering company in the London area. These vacancies occur owing to normal expansion of company business. Applicants should have a comprehensive experience of small to medium class production of electronic equipment with special emphasis on Ministry contracts. These are attractive vacancies and call for men of sufficient ability and initiative to justify salaries ranging between £750 and £1,000 per annum. All staff privileges including superannuation and insurance schemes are available to the selected candidates. Applications, which should give full details of qualifications and experience, should be addressed to Box No. W 2629.

SENIOR TRANSFORMER DESIGNER required with experience of all types of transformers up to 3 000 kVA. Excellent prospects for an energetic man capable of supervising junior engineers. Excellent working conditions, Pension Scheme, Canteen, etc. West London area. Applications to Box No. W 1157.

SERVOMECHANISMS ENGINEER required by Gloucestershire firm for theoretical work on aircraft automatic control systems. Good Honours Degree and sound experience necessary. Apply quoting reference 46/EN. to Box No. W 1238.

TECHNICAL ADVERTISING ASSISTANT required for Publicity Division of Mullard Ltd. A knowledge of electronics to at least O.N.C. standard essential as duties include the preparation of technical material for catalogues, exhibitions and advertisements. This is an interesting and progressive post in an expanding organization. Pension scheme and good staff conditions. Starting salary according to qualifications. Write giving age and full details of education and previous experience to Personnel Officer, Mullard Ltd., Century House, Shaftesbury Avenue, London, W.C.2. W 2666

SENIOR INSTALLATION DESIGN Draughtsmen are required at Supermarine Division of Vickers-Armstrongs Ltd. for Electrical, Electronic and/or Radio, Radar Aircraft Work. Excellent positions for the right men able and willing to take responsibility, show initiative and follow the job through. The first requirement is for men with similar aircraft experience, but applications will be welcomed from others who have experience in the electrical or radio industry associated with aircraft and the like. Full details stating age, salary, etc., to Personnel Dept., Vickers-Armstrongs Ltd., Supermarine Works, Hursley Park, Near Winchester. W 2699

TECHNICAL ASSISTANT required for Designs Office. Knowledge of capacitor manufacture desirable, but Engineers with experience of valve manufacture will be considered. Write giving details to A. H. Hunt (Capacitors) Ltd., Bendon Valley, Garratt Lane, S.W.18. W 1222

TECHNICAL ASSISTANTS required for investigational work in connexion with radio valve manufacture. Applicants should possess at least Higher National Certificate. Five-day week, modern welfare facilities, staff pension. Apply, giving full personal details, including age, qualifications and experience, to Personnel Superintendent, The Edison Swan Electric Company Limited, Cosmos Works, Brimsdown, Enfield, Middlesex. W 2692

TECHNICAL ASSISTANTS required for interesting research and development work at the Mullard Research Laboratories. Applicants should preferably have had previous experience in electronic circuitry and in possession of the Ordinary National Certificate, or technically educated to this standard. Ex-Service candidates with radar or radio experience will be considered. Excellent conditions of employment including Pension Scheme. Apply Personnel Officer, Mullard Research Laboratories, Cross Oak Lane, Salfords, Near Redhill, Surrey. W 2710

1. TECHNICIANS. Several vacancies are available for technicians and men having design experience and holding 1st Class Honours Degree in Mechanical Engineering and having practical experience preferably in Marine Engineering or alternatively experience on the Mechanical side for the generation of power for land purposes. They are required for work on the production of power from atomic energy, and will be employed initially at Harwell. Age 27-35. Good salaries will be paid to men holding the necessary qualifications. 2. Draughtsmen. Several vacancies are available for draughtsmen holding Higher National Certificates for work on the production of power from atomic energy. Work would be initially at Harwell. Age 30 or over. Good salaries will be paid to men having the necessary experience. 3. Senior Project Engineer. A vacancy is available for a Senior Project Engineer to head a group for the production of power from atomic energy. Applicants should have a background of experience, preferably in Marine Engineering, or alternatively experience on the Mechanical side of the generation of power for land purposes. In addition, applicants should have scientific qualifications in the form of 1st Class Honours Degree in Marine or Mechanical Engineering and should for preference be in the range 35-40. Good salary will be paid to a man meeting the stated requirements. Employment will be at Harwell initially. Box No. W 1203.

TELEPHONE ENGINEER required by large firm of communication engineers in London area for carrying out development work on transmitters and receivers for high quality line transmission. Good prospects, pension scheme. State age, qualifications, experience and salary required. Box No. W 2663.

TELEVISION DESIGNER required. The successful applicant must have a sound theoretical knowledge of fundamentals and experience of Time Base work would be an advantage. Applications including full details of experience and qualifications should be addressed to Personnel Department, Murphy Radio Limited, Welwyn Garden City. W 1227

TEST ENGINEERS are required to assist in the production of a variety of precision electronic laboratory instruments. Previous Test Department experience essential (preferably in connexion with Electronic Measuring Instruments). Salaries in the range £450-£575 p.a. according to qualifications and experience. Apply stating full details to the Personnel Manager, Furzehill Laboratories Ltd., Boreham Wood, Herts. W 2696

TEST ENGINEERS required in connexion with the production of telephone transmission equipment. Technical qualifications to O.N.C. or equivalent standard preferred, but well experienced applicants without such qualifications will be considered. Interesting work, good salaries and conditions, bonus scheme. Apply Personnel Manager, Telephone Manufacturing Co. Ltd., Sevenoaks Way, St. Mary Cray, Kent. W 2619

TEST ENGINEERS required for interesting work in connexion with Radar, Television Film Projectors, Camera Channels, Microwave Links and similar electronic equipment. Applicants must have sound theoretical knowledge of electronics backed by practical experience in H.M. Forces or industry. Staff positions and Superannuation Scheme. Single lodging accommodation available. Apply giving full details to the Personnel Dept. (CE/21), E.M.I. Ltd., Hayes, Middlesex. W 2694

THE ASSOCIATED ETHYL COMPANY LIMITED have the following vacancy at their Engine Laboratory, Bletchley. Engineer or Physicist with Degree, for the design, development and construction of instruments for use in research programmes on I.C. Engines and I.C. engined vehicles. The starting salary for this position will be commensurate with age, qualifications and experience. The laboratory is equipped with a cafeteria where subsidized lunches are served. The selected applicant will be eligible to join the Company's Contributory Pension Scheme. Applications giving brief particulars of age, education, qualifications and experience should be sent to: The Office Controller, The Associated Ethyl Company Limited, Engine Laboratory, Watling Street, Bletchley, Bucks. W 2735

THE ASSOCIATED ETHYL COMPANY LIMITED require an Engineer or Physicist with Degree, for the design, development and construction of instruments for use in research programmes on I.C. Engines and I.C. engined vehicles, at their Engine Laboratory, Bletchley. The selected candidate will be eligible for recommendation to the Local Council in respect of housing. Attached to the Laboratory is a cafeteria where subsidized lunches are served. The selected candidate will be eligible to join the Company's Contributory Pension Scheme. Applications, giving particulars of age, education, qualifications and experience, should be sent to: The Office Controller, The Associated Ethyl Company Limited, Engine Laboratory, Watling Street, Bletchley, Bucks. W 2647

THE ENGLISH ELECTRIC CO.'S GUIDED WEAPONS Division have vacancies at Luton for Senior Engineer Inspectors. The work will require close liaison with flight trials and design engineers and may involve participation in trials away from base. Applicants should have H.N.C. (Electrical) or equivalent qualifications and have several years' experience covering two or more of the following: (1) Electronics (D.C. Amplifiers, Pulse Circuits or Microwaves). (2) Gyros. (3) Hydraulics. (4) Servo Systems. These are Senior appointments carrying attractive salaries and are pensionable after qualifying period. Housing assistance can be given to successful applicants normally resident in the Greater London area. Applications to Dept. C.P.S., 336/7, Strand, W.C.2, quoting Ref. 1355E. W 2701

THE GENERAL ELECTRIC CO. LTD., Brown's Lane, Allesley, Coventry, requires Mechanical Development Engineers, Designer-

CLASSIFIED ANNOUNCEMENTS
continued on page 11

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

Draughtsmen and Draughtsmen, preferably with experience of Radar type equipments for work on Guided Weapons and like projects. Also required, Senior and Junior Electronic Development Engineers, particularly in the field of Microwave and Pulse Applications. Salary according to age, qualifications and experience. Apply by letter stating age and experience to the Personnel Manager. Ref. R.G. W 208

THE GENERAL ELECTRIC CO. LTD. have vacancies for Television Service Engineers at their Service Depot in Westminster. Excellent opportunities exist for those having had previous experience. The positions are pensionable and the Depot operates a five-day week. Apply in writing, quoting Ref. S.D., to the Staff Manager, Magnet House, Kingsway, W.C.2. W 1226

THE MULLARD RADIO VALVE CO., invites applications for the following vacancies in its Special Valve Division. V.H.G. (A)—Applications Group. 1. A Senior Electronic Engineer to control a group concerned with work on the fundamental problems connected with Gas Filled Valves. An aptitude for the design of new circuits would be a particular advantage. In addition the appointment calls for a person who would be able to offer advice and assistance on the application of the finished product. An essential qualification is an Hons. Degree coupled with practical experience in this or an allied field of work. 2. A Physicist to work on fundamental problems connected with the application of Gas Filled Valves. The work will involve assistance and advice on the application of the finished product. The minimum qualification for this appointment is an Hons. Degree of Physics and previous experience is desirable although not essential. 3. An Electronic Engineer to work on specialized circuit problems associated with Gas Filled Valves. The successful applicant will, in addition, be expected to offer advice and assistance on the application of the finished product. A B Sc. pass Degree or equivalent qualification together with experience in this or an allied field of work is desirable. V.H.G. (B)—Equipment Design Group. 1. An Electronic Engineer to supervise a group concerned with the design of equipment, for the testing of Gas Filled Valves. The work will also involve giving advice and assistance in the construction of this type of equipment and to supervise the construction of experimental circuits to meet new demands and applications. A B.Sc. pass Degree or equivalent qualification together with some experience in this or an allied field is desirable. Applications are particularly invited from candidates having an interest in circuitry. 2. A Technical Assistant to design Test Equipment for Gas Filled Valves. The duties will involve the consideration of experimental circuits for use with these types. Applications are invited from candidates who have experience in circuit techniques and who should preferably possess a Higher National Certificate or equivalent qualification. The vacancies outlined above are at the Company's Mitcham factory and are due to the expansion of its activities in this field. Salaries will be according to individual age, experience and qualifications and can be considered as progressive. There are facilities for further training, a Company Pension Scheme, Long Service Plan, and conditions of employment generally can be considered to be of a high standard. Applications in writing, which will be treated with the strictest confidence, should be addressed to The Personnel Officer, The Mullard Radio Valve Co. Ltd., New Road, Mitcham Junction, Surrey, quoting the appropriate reference number. W 2711

THE PLESSEY COMPANY LIMITED invite applications for the position of chief engineer for its newly-formed Radar and Electronics Laboratories situated at Manor Way, Boreham Wood, Herts. Replies, which should give full details of qualifications and experience, should be addressed for the attention of Mr. J. Rhys-Jones at the above address. W 2714

THE PLESSEY COMPANY LIMITED of Ilford offer attractive permanent positions to Draughtsmen, due to expansion of our electronic division. Applicants should be experienced in development and design for production of high grade communications equipment to service requirements. Good salary and staff conditions. Company superannuation and insurance scheme in operation. Applications, which will be treated in confidence, should be addressed to The Plessey Company Limited, Vicarage Lane, Ilford, Essex. W 2631

TRAINING BY EXPERTS for a career in a specialized branch of light electrical engineering is open to students in the age group 20-25. Candidates must have been educated to Inter B.Sc. standard in physics or chemistry. After a training period of three years, promotion in this new and well-equipped laboratory would be offered to those applicants who have shown outstanding ability during the qualifying period. Attractive salaries are payable for these posts and the Company operates a Pension Scheme. Replies in confidence quoting C.L.1, to Box No. W 2642.

TRANSFORMER DESIGNER required for development projects involving audio-frequency power transformers, pulse transformers, oil-filled units, etc. Apply stating age, qualifications and experience to the Personnel Manager (Ref. R.G.), The General Electric Co., Ltd., Brown's Lane, Allesley, Coventry. W 192

ULTRA ELECTRIC LIMITED, Western Avenue, Acton, London, W.3. Radio and Television Development Engineers. (a) Applications are invited from Senior Development Engineers with experience and Academic Qualifications for important work on new development projects. The posts are permanent and pensionable and offer scope for the right men to work in ideal conditions in modern, well-equipped Laboratories. Please write in strict confidence to the Personnel Manager for an interview appointment. (b) Junior Engineers (aged 21/29) are also required, and applicants for these posts should have some technical training and preferably previous experience. Please write as above. W 2500

ULTRA ELECTRIC LIMITED, Western Avenue, London, W.3. Electronic Development Engineers are required in all grades for work on (a) subminiaturization of V.H.F., radio and audio circuitry, (b) transistor applications, (c) V.H.F. communication, (d) pulse techniques, (e) radar and radio navigation. Applications are invited from (a) Senior Development Engineers with Degree or equivalent qualifications, and more than five years' experience in one or more of the above fields. (b) Junior Engineers with Degree or H.N.C. with or without experience for work in the above fields. (c) Test Equipment Development Engineers with experience of design of test equipment to meet production requirements. The posts are permanent and pensionable, and offer scope for the right men to work in ideal conditions in modern, well-equipped Laboratories. Please write in strict confidence to the Personnel Manager for an interview appointment. W 2501

VACUUM PHYSICIST.—Qualified physicist or equivalent, required for research and development of instruments and apparatus including electron, optical, mechanical and ionization devices. Previous high vacuum experience a distinct advantage. Permanent Pensionable position. Housing available. Commencing salary according to age and experience and commensurate with first-class man sought. Detailed applications to Personnel Officer, W. Edwards & Co. (London) Limited, Manor Royal, Crawley, Sussex. W 2717

VALVE PRODUCTION ENGINEER required to take charge of small manufacturing section in an established works in N.W. London. Must be experienced in production control of transmitting and similar type valves and conversant with all processes. Please state experience, age, and salary required to Box No. W 1237.

WIREMEN required for the laboratory of an engineering company situated in the East London area. Applicants should have had previous experience of electronic computors and ancillary equipment. These are staff appointments and a good salary will be paid to the selected candidates. Please reply, giving details of past experience to Box No. W 2627.

WOOL INDUSTRIES RESEARCH ASSOCIATION. Engineer or Physicist (male, preferably graduated) with knowledge of electronics, required for design and construction of instruments in textile research laboratory; mechanical ability essential. Commencing salary in the range £425-£600 p.a., with F.S.S.U. according to age and experience. Applications to Wool Industries Research Association, Torridon, Headingley, Leeds, 6. W 1220

Further "Situations Vacant" advertisements appear in display for mon pages 98, 101, 113, 115 and 118:

SITUATIONS WANTED

CAN ANYBODY USE an adaptable and versatile Engineer, 36, with H.N.C., who prefers variety to specialization? Experience includes mechanical (12 years). Electrical and Electronic (8 years); able to think for himself and work without supervision. Fully mobile, own workshop available if preferred. Box No. W 1216.

SERVICE

CAPACITY available (immediate) for light assembly, wiring, soldering, cable forming, etc., up to 2,000 operator hours weekly. Long or short runs. Competitive prices. Well-known Company. Highest credentials. A.I.D. Approved. Works situated in Greater London area. Box No. W 2672.

MACHINE ENGRAVING and Dividing on metals and plastics. Good delivery. Parco Works, Albion Road, Horsham. Telephone: HORsham 2273. W 1155

TRACING. Capacity available for high quality tracing work. We specialize in converting drawings from commercial to government specifications including I.D.P.13. Multiplex Drawings, Bromley Lodge, High Street, Bromley, Kent. Tel.: Ravensbourne 8220. W 1229

WEBB'S SERVICE DEPT. for complete renovation of complex communication receivers of any make. Test report issued showing sensitivity selectivity, signal/noise equal to, or better than, maker's original figures. Webb's Radio, 14 Soho Street, London, W.1. W 196

CLASSIFIED ANNOUNCEMENTS
continued on page 12

WANTED

COPIES of Electronic Engineering for 1947 and 1948. Box No. W2718.

SCRAP MERCURY urgently needed: any quantity: Highest prices paid on collection or delivery: also aircraft plugs, electrical Contacts, Magnetic points (new or used) precious, high grade and non-ferrous metal in any form: inquiries to Belgrave Buyers, 5 Belgrave Gardens, London, N.W.8. Mai. 7513. W 1217

FOR SALE

"AMPLITUDE—Frequency Characteristics of Ladder Networks," by E. Green, M.Sc., with foreword by M. Dishal of Federal Telecommunication Laboratories, U.S.A. This book, destined to be a world standard source of modern network theory design information, deals with the synthesis of ladder networks to give either Butterworth or Chebyshev amplitude response in the passband. It includes solutions for any ratio of terminal loads with applications to low pass and bandpass networks, and practical examples. A "Marconi Review' publication obtainable from Marconi's Wireless Telegraph Co. Ltd., Marconi House, Chelmsford, Essex. Price 25s. post free. W 2687

GERMANIUM DIODES 1s. each. Quantities cheaper. BDC, 591 Green Lanes, London, N.8. W 1178

HIGH VACUUM EQUIPMENT. A quantity of used K4 Mercury Vapour Pumps, Box Pumps and Process Timers now surplus to requirements. Inquiries to Box No. W 1234.

J.SOC.MOT.PIC.ENGRS. June 1948-June 1954; Tele-Tech. Mar. 1949-Nov. 1952; J. Acoust. Soc. Amer.—July 1948-March 1954; R.C.A. Rev.—June 1948-March 1954; Bell Syst. Tech. J.—Oct. 1948-Nov. 1952; Elect. Engineering, N.Y. Jan.-Dec. 1952. Odd copies: Proc. I.R.E. 1941-1953; Wireless Engr. 1948-1954; B.B.C. Quart. 1946-1954. Offers and requests to M.S.S. Recording Co. Ltd., Poyle Close, Poyle Road, Colnbrook, Bucks. W 2698

MAGSLIPS at 1/10th to 1/20th of List Prices. Huge stocks. Please state requirements. K. Logan, Grove Road, Hitchin 1744, Herts. W 183

MAGSLIPS, SELSYNS and many other items connected with automatic and remote control mechanisms are marketed by Servo & Electronic Sales Ltd. Brochure available on request. See our display advertisement on page 115. W 202

METALWORK. All types cabinets, chassis racks, etc., to your own specifications. Philpott's Metal Works Ltd. (G4BI), Chapman Street, Loughborough. W 2294

SINE-COSINE RESOLVERS (3 in. Magslip Transmitters No. 5, AP 10861). Brand new, each in maker's tin. Offered in quantity at less than one-tenth of cost. Export inquiries invited. P. B. Crawshay, 166 Pixmore Way, Letchworth, Herts. W 153

STAINLESS STEEL BALLS, Phosphor Bronze and Brass Ball's, Miniature Balls and Bearings; prompt delivery. Insley (London) Ltd., 21/22 Poland Street, London, W.1. Tel. GERrard 8104 and 2730. W 1177

X-RAY RADIATION PROTECTION: Lead-Glass Sheets (Cuthbert Andrews Super-Protex) 10" × 12" × 5/16", 65s. each; or, complete with fluorescent screens, 105s. each. Ex-Admiralty. F. S. Henry, A.M.Brit.I.R.E., 220B Canterbury Street, Gillingham, Kent. Tel. 59203. W 1224

AGENCIES

BRITISH ENGINEER/PHYSICIST now resident in Canada contemplates opening agency for specialized equipment, and wishes to contact manufacturers interested in placing their products in Canada. Box No. W 1197.

EDUCATIONAL

BOROUGH POLYTECHNIC. Mechanical Engineering Department. A course of five lectures on the writing of Technical Reports will be given by Mr. G. Parr, M.I.E.E., at the Borough Polytechnic, S.E.1, on Thursdays at 6.30 p.m., commencing on 20th January, 1955. The fee for the course is £1 1s. 0d. The course will cover the preparation of reports, collection of data and practical advice on the submission of papers and publications. Enrolment forms can be obtained from the Secretary, Borough Polytechnic, Borough Road, S.E.1. W 2715

CITY & GUILDS (Electrical, etc.) on "No Pass—No Fee" terms. Over 95 per cent successes. For full details of modern courses in all branches of Electrical Technology send for our 144-page handbook—Free and post free. B.I.E.T. (Dept. 337C), 29 Wright's Lane, London, W.8. W 142

ELECTRONICS APPLIED TO INDUSTRY. Learn the basic principles and applications with our modern self-study course. Experimental work included if required. Free Brochure from E.M.I. Institutes, Dept. EE.56, London, W.4. (Associated with H.M.V.) W 2673

FREE; Brochure giving details of courses in Electrical Engineering and Electronics, covering A.M.Brit.I.R.E., City and Guilds, etc. Moderate fees. Write to E.M.I. Institutes, Dept. EE.29, London, W.4. (Associated with H.M.V.) W 2674

T.V. AND RADIO—A.M.Brit. I.R.E., City & Guilds, R.T.E.B. Certificate, etc., on "No Pass—No Fee" terms. Over 95 per cent successes. Details of Examinations and Home Training Courses in all branches of Radio and T.V. Write for 144-page handbook — Free. B.I.E.T. (Dept. 337H), 29 Wrights Lane, London, W.8. W 187

The NEW "AIRMAX" 1½" Diam. FAN

The fan illustrated is one of our range of ELECTRONIC, AIRCRAFT, INDUSTRIAL AND MARINE FANS. Engineered in accordance with K114, RCS1000 and other relevant Ministry specifications.

This small fan can be fitted with alternative rotors for :-
High Volume with Low Pressure,
Low Volume with High Pressure
or any Intermediate Duty.

Available in quantity on 6v, 12v, 24v, or fitted with specially constructed B.T.H. 115v, 400c/s, 3 ph. motor

TO APPROVED MINISTRY SPECIFICATIONS

Designed by the world pioneers of high efficiency axial flow fans.

A. K. FANS LIMITED

20 UPPER PARK ROAD · LONDON · N.W.3

Telephone: PRIMROSE 5969

CONTRACTORS TO ADMIRALTY, M.O.S., etc. A.I.D. APPROVED MANUFACTURERS OF "AIRMAX" PATENTED SCREW FANS

Announcing . . .

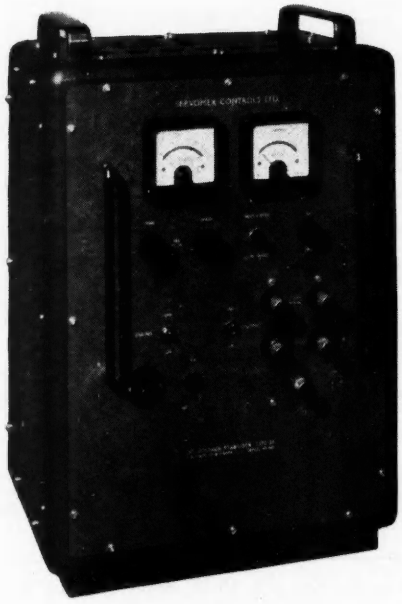
a NEW 2·5 Amp

Quick Response

SERVOMEX

DC VOLTAGE STABILISER

TYPE 38



Descriptive leaflet on request

A purely electronic stabiliser of substantial current rating, for work of the highest precision, where a quick response is needed

Range 1 to 15 volts D.C.

Current 0 to 2.5 amps continuous rating.

Regulation against changes of load—less than 5 millivolts for 2.5 amps load.

Stability against changes of mains voltage—plus or minus 5 millivolts for voltage swings of plus or minus 10%.

Time of response—the time for *full correction* is from 1 millisecond for small currents, to 5 milliseconds when 2.5 amps is suddenly switched.

Ripple—less than 3 millivolts RMS.

SERVOMEX CONTROLS LIMITED

Crowborough Hill, Jarvis Brook, Sussex

Telephone: Crowborough 1247

ALL-POWER
REGULATED POWER SUPPLIES

SERIES 500

An entirely new range of units, designed for the highest possible performance and overall efficiency.

Now in large scale production and available for prompt delivery.

Model 501
(fitted with end frames)

ABRIDGED DATA
(Further information on request)

	Data	Model 501	Model 502	Model 503	Model 504	Model 505
Main +VE Stabilizer	Output	200-500V 250mA	200-500V 250mA	0-500V 250mA	0-500V 250mA	0-500V 150mA
	Number of Ranges	2	2	4	4	1
	Voltage Stabilization	±0.02%	±0.002%	±0.1%	±0.002%	±0.1%
	Effective Output Resistance (max.)	0.2 Ω	0.02 Ω	0.5 Ω	0.02 Ω	0.5 Ω
	Output Ripple (rms. max.)	2mV	1mV	3mV	1mV	3mV
−VE Supply Stabilizer	Outputs	—	—	250V 25mA 0—250V 1mA	250V 25mA 0—250V 1mA	250V 25mA 0—250V 1mA
	Voltage Stabilization	—	—	±0.05%	±0.002%	±0.05%
	Output Resistance (max.)	—	—	1 Ω	0.01 Ω	1 Ω
	Output Ripple (rms. max.)	—	—	2mV	1mV	2mV
Unstabilized +VE H.T. Supply 250mA max.		470V 630V	470V 630V	320V 470V 630V	320V 470V 630V	630V
Unstabilized A.C. Supply		6.3V 10A	6.3V 10A	6.3V 10A	6.3V 10A	6.3V 10A
Price		£70	£91	£81	£99	£75

STANDARD UNITS. All models are supplied as standard for mounting in 19 in. racks and are fitted with fully protective covers.

EXTRAS. To convert from rack mounting to bench use the following extras are available :—

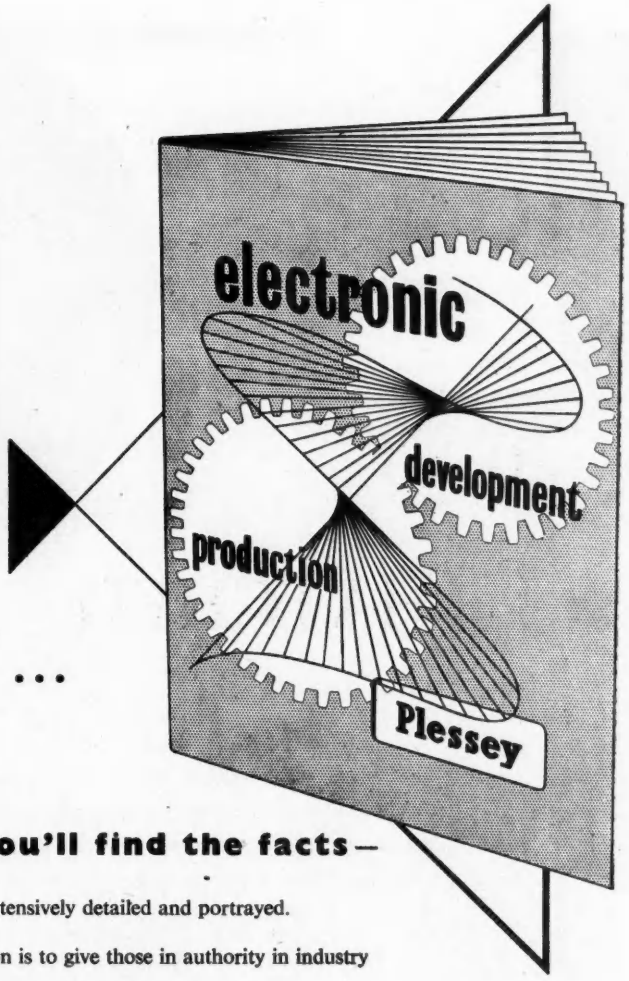
Polished hard-wood reinforced end frames ... ... £1 15 0 per pair

Steel instrument case of new design ... ... £4 10 0 each

PRICES. Prices are quoted net ex works and are subject to variation without notice.

ALL-POWER TRANSFORMERS LTD. . CHERTSEY ROAD, BYFLEET, SURREY.
Tel. : BYFLEET 3224/5

BETWEEN THE COVERS OF THIS IMPORTANT BOOK ...



... you'll find the facts—

about the Plessey Electronics Division extensively detailed and portrayed.
The primary intention of this publication is to give those in authority in industry
a profitable glimpse of the unique facilities for research,
development and manufacture of electronic equipment
available to them through the Plessey organisation.
You will, no doubt, like details of these activities in order to assess their value to
you. A card or a 'phone call will ensure that a copy of
"Electronic Development and Production" is despatched to you immediately.

...the inside story of the Plessey Electronics Division

—a powerful force in precision electronics production today.

The Plessey Company Limited · Ilford · Essex · Electronics Division · Telephone: Valentine 8855

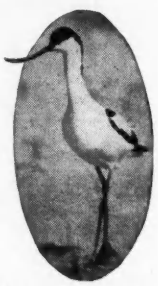
PE4a

A remarkable photograph by Eric Hosking, F.R.P.S. of a newly hatched Avocet.

JUST HATCHED

An entirely new " Avo " Signal Generator has been developed and production will commence in the near future. The new instrument has a wide frequency coverage and has been specially designed to meet the requirements of the existing and proposed new Television and Frequency Modulation stations.

- Directly calibrated in frequency with a continuous band from 5 to 230 Mc/s over a scale length of approximately 60 inches.
- A special device enables precise frequency setting and discrimination over a narrow band anywhere within the main frequency range.
- A separate expanded scale covers the frequency modulation stations.
- A single switch selects CW, sine-wave modulated AM, square wave modulated AM and frequency modulated signals.
- The instrument is fitted with a comprehensive attenuator system.
- R.F. signal can be modulated from an external source.
- Internal modulation signals available for L.F. testing.



The Avocet, a rare species of bird which has returned to breed in England after an absence of a century, has been adopted by us and has been registered as our Trade Mark.

Fuller details and specification will be available shortly. Ask us to put your name on our mailing list.

THE AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO., LTD.
WINDER HOUSE · DOUGLAS STREET · LONDON · S.W.1. Telephones: VICtoria 3404 (9 lines)

This, together with other new designs for 1955, is fully described in the 1955 edition of Marconi Instruments Catalogue.

MARCONI INSTRUMENTS

SIGNAL GENERATORS · BRIDGES · VALVE VOLTMETERS · Q METERS · WAVEMETERS
FREQUENCY STANDARDS · WAVE ANALYSERS · BEAT FREQUENCY OSCILLATORS

MARCONI INSTRUMENTS LTD · ST. ALBANS · HERTS · Phone: ST. ALBANS 6160/9

30 Albion Street., Kingston-upon-Hull. Phone: Hull Central 16144. 19 The Parade, Leamington Spa. Phone: 1408

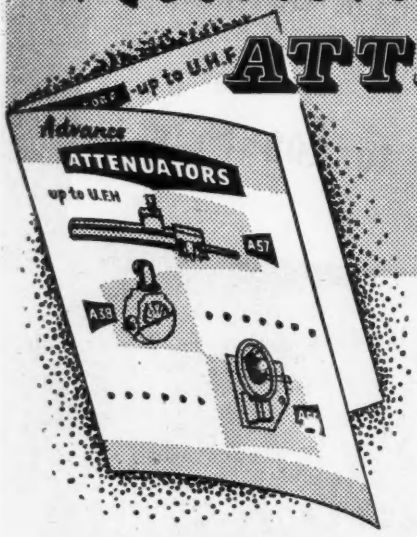
Managing Agents in Export:

MARCONI'S WIRELESS TELEGRAPH CO. LTD · MARCONI HOUSE · STRAND · LONDON, W.C.2

TC59

DETROIT PUBLIC LIBRARY

Advance ATTENUATORS



–in this folder.....

..... are full technical data and dimensioned drawings of the present range of "Advance" attenuators — a range that covers the frequency spectrum from the lowest to Ultra High Frequency. Originally designed for use in Signal Generators these three types find many applications where a variable attenuator element is required following a signal source. Send for this informative data.

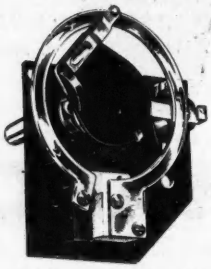
Ask for Folder M/24

TYPE A57
PISTON ATTENUATOR

Output Impedance....75 ohms
Attenuation Range.....125 db

£47·10*

TYPE A55
INDUCTANCE SLIDE WIRE ATTENUATOR



Inductance..... 0.1 μH
Attenuation Range..... 20 db

£3·15*

TYPE A38
STEP ATTENUATOR

Impedance..... 75 ohms
Maximum Attenuation.. 80 db

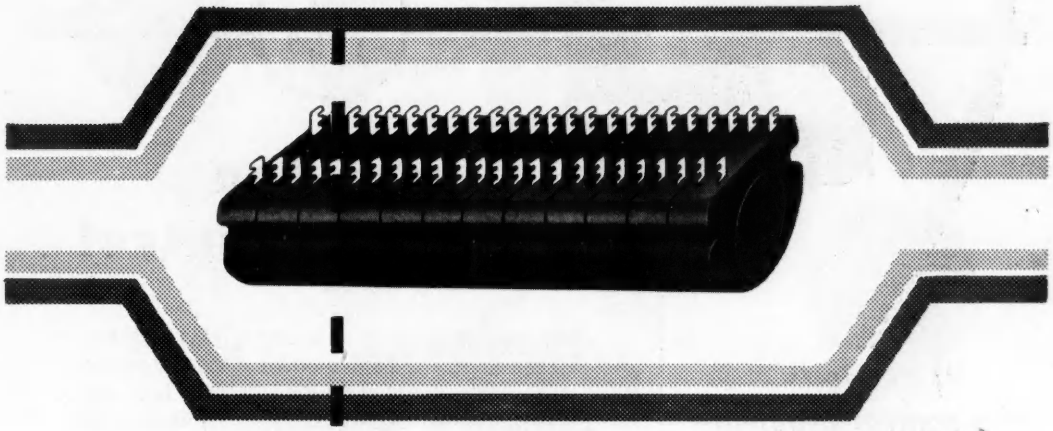
£5*

(*Without resistors Type A 37.....£4·5*)

* *Nett Price in U.K.*

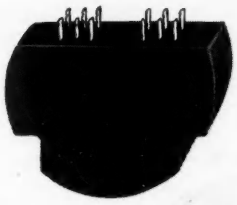
ADVANCE COMPONENTS LIMITED · MARLOWE RD · WALTHAMSTOW · LONDON · E 17
'Phone : LARkswood 4366/7/8 'Grams : Attenuate, Walt, London.

Loading coils inside the cable splice



The advantages of the splice loading technique are particularly marked in the loading of small cables of up to 74 pairs. The coils can be included in a jointing sleeve or unit of only slightly larger diameter than would normally be used.

The loading coils in the Mullard L.160 Series are designed specifically for this technique. They are cast in resin, which provides complete protection from climatic conditions and allows a telephone administration to store them ready for building into loading units as and when required. Both single and triple assemblies are available for different sizes of cable.



TRIPLE COIL ASSEMBLY

Ferroxcube pot cores give these coils certain electrical advantages over conventional types, particularly in the loading of higher frequency circuits such as those encountered in programme and carrier applications.

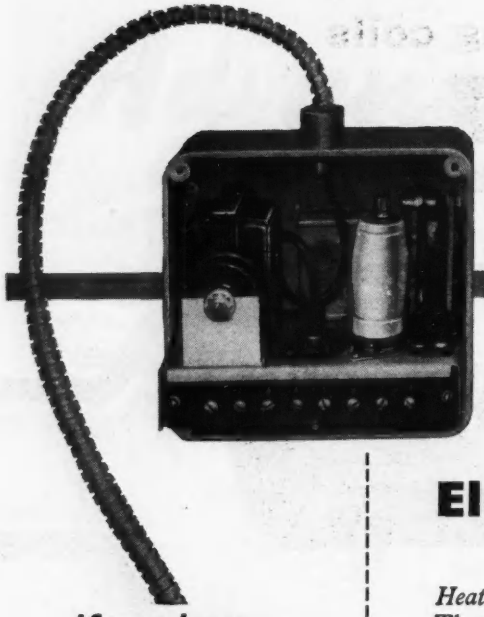
You are invited to write for leaflets describing the Mullard L.160 Series coils and simple units for pole and splice loading.

Mullard

SPECIALISED ELECTRONIC EQUIPMENT

MULLARD LTD · EQUIPMENT DIVISION
CENTURY HOUSE · SHAFTESBURY AVENUE · WC2

(MI453)



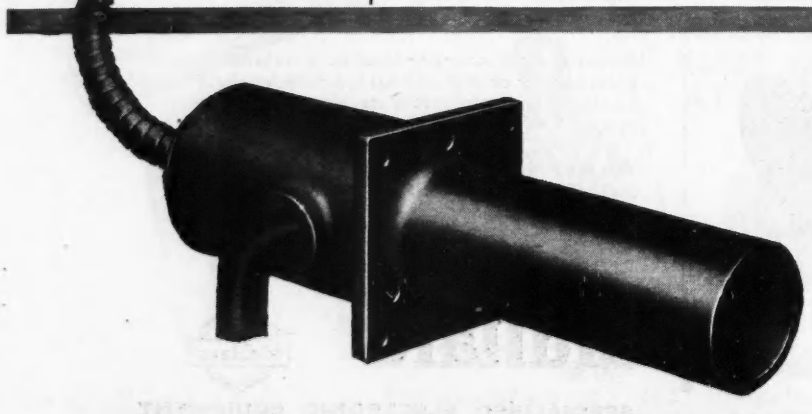
B
T-H

Infra-Red Electronic Control

If you have a control problem— consult BTH

Heat rays effect on/off switching of electric power. The use of infra-red radiation for automatic control has a wide field of application in both light and heavy industries. British Thomson-Houston offer unrivalled design and manufacturing facilities for the production of both standard and special equipments, for duties at temperatures ranging from the very highest down to below 100°C.

The illustration below shows a special water-cooled cell housing, with associated relay (top) for automatic control of bloom cutting machines and cooling beds in steelworks—just one example of the versatility of BTH infra-red control systems.



BRITISH THOMSON-HOUSTON

THE BRITISH THOMSON-HOUSTON COMPANY LIMITED · RUGBY · ENGLAND

Member of the AEI group of companies

A48[illegible]

...are in capable hands

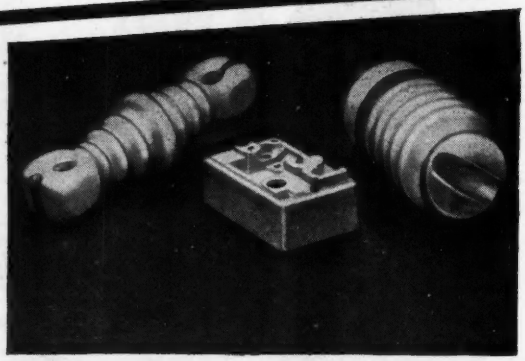
MARCONI

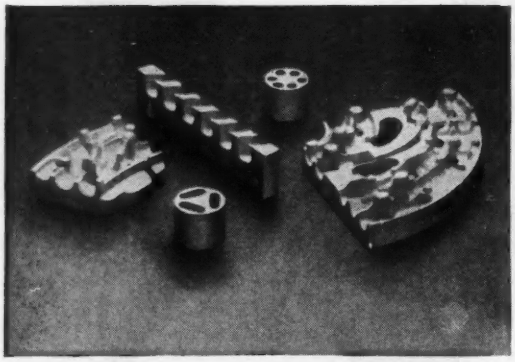
MARCONI'S WIRELESS TELEGRAPH
COMPANY LIMITED · CHELMSFORD · ESSEX

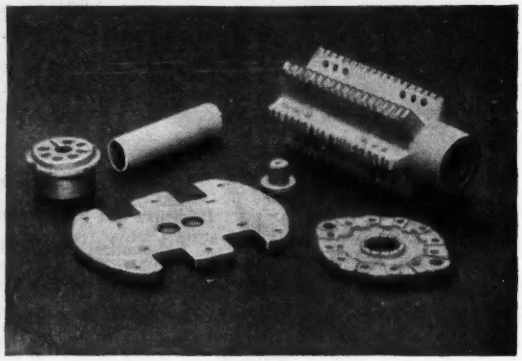
LG6

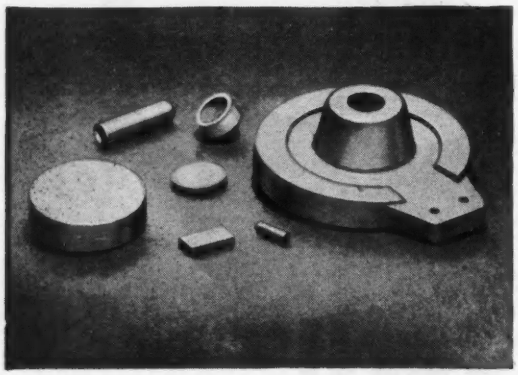
Bullers CERAMICS
FOR INDUSTRY

High quality material and dimensional precision are attributes of Bullers die-pressed products.
Prompt delivery at competitive prices.









We specialise in the manufacture of

PORCELAIN
for general insulation

REFRACTORIES
for high-temperature insulation

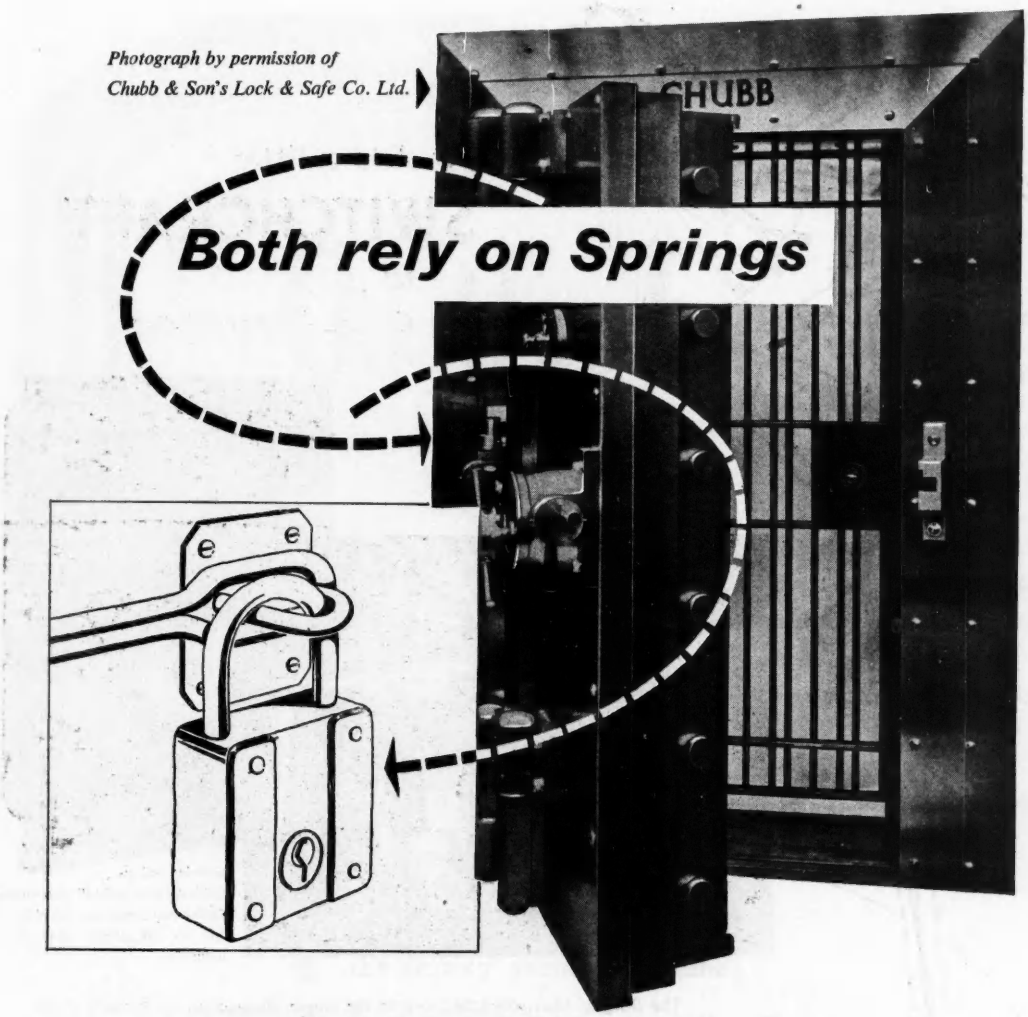
FREQUELEX
for high-frequency insulation

PERMALEX & TEMPLEX
for capacitors

BLI28

BULLERS LIMITED
MILTON · STOKE-ON-TRENT · STAFFS
Phone: Stoke-on-Trent 21381 (5 lines) · Telegrams & Cables: Bullers, Stoke-on-Trent
Ironworks: TIPTON, STAFFS Phone: Tipton 1691
London Office: 6 LAURENCE POUNTNEY HILL, E.C.4 Phone: MANsion House 9971

Photograph by permission of
Chubb & Son's Lock & Safe Co. Ltd.



Both rely on Springs

reliable Springs by

From the high precision spring required for a strongroom door to its simpler counterpart in a padlock, the right spring for the job is essential to ensure perfect performance. When your springs are designed and made by Salter, they are just right — not the cheapest obtainable but fit to work for ever.

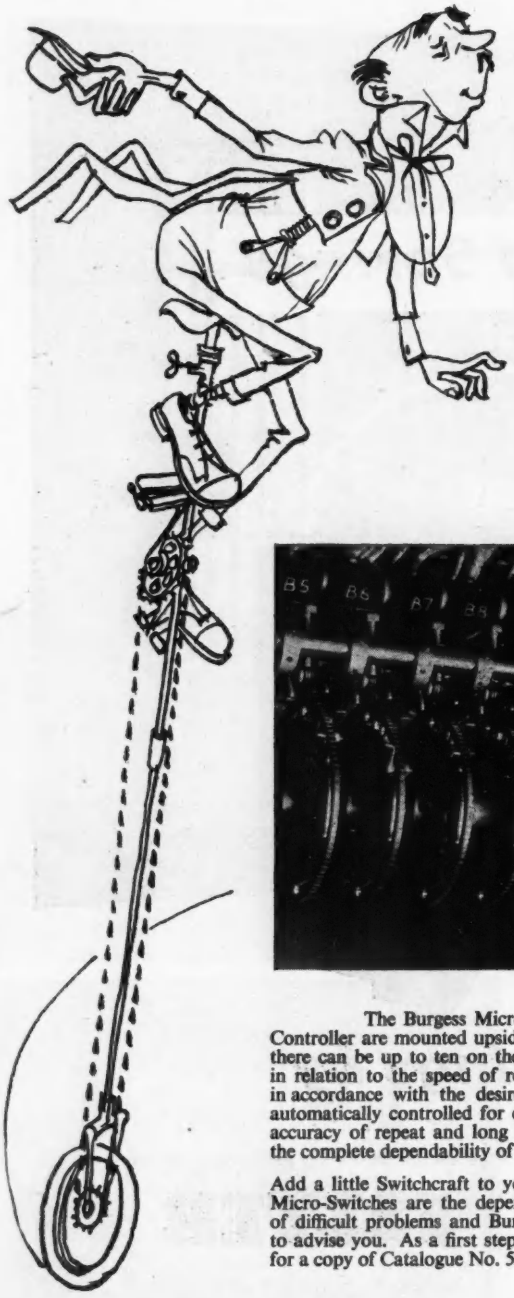
SALTER

Service to Engineers since 1760

A tradition of quality in craftsmanship and materials is embodied in every Salter spring — you can depend on Salter for the *right spring for the job.*

Geo. Salter & Co. Ltd., West Bromwich

M-W.381

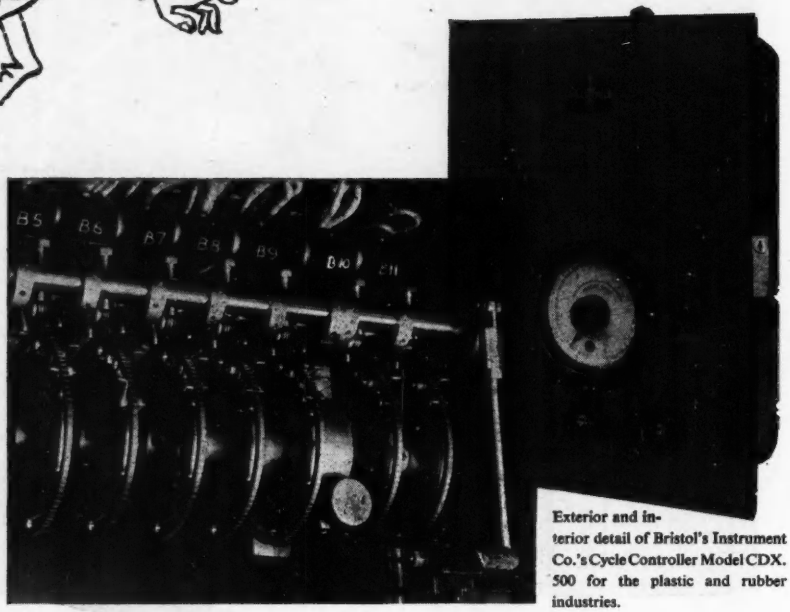


Add a little

SWITCHCRAFT

to

Cycle Controlling



Exterior and interior detail of Bristol's Instrument Co.'s Cycle Controller Model CDX. 500 for the plastic and rubber industries.

The Burgess Micro-Switches seen in the above photograph of Bristol's Cycle Controller are mounted upside down and are operated by dogs locked to cams of which there can be up to ten on the camshaft. The actuating devices are most carefully timed in relation to the speed of revolution of the camshaft to operate each switch precisely in accordance with the desired programme. In this manner up to ten processes are automatically controlled for cycle durations ranging from 20 seconds to 5 minutes. The accuracy of repeat and long life of the Burgess Micro-Switches are factors upon which the complete dependability of the instrument relies.

Add a little Switchcraft to your products too—Burgess Micro-Switches are the dependable answer to all sorts of difficult problems and Burgess engineers are waiting to advise you. As a first step, please write or telephone for a copy of Catalogue No. 50/E.

Type CRW2. The type of Burgess Micro-Switch employed in this application is a standard model available from stock. The strong actuating lever requires a force of only 1 oz. max. to operate.

BURGESS MICRO-SWITCHES

Industry's Automatic Choice

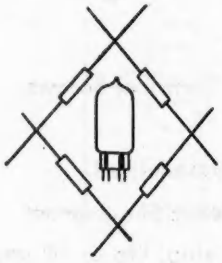
BURGESS PRODUCTS CO. LTD., Micro-Switch Division, Dukes Way, Team Valley, Gateshead 11. Telephone : Low Fell 75322 (3 lines). Telegrams : MICRO, Gateshead.

On the face of it

. . . it is evident that BRIMAR high-grade cathode-ray tubes meet the most exacting specifications of television and electronic equipment manufacturers.

And detailed examination of the company's resources and experience in this field reveal that BRIMAR introduced :—

- **the first mass produced aluminised cathode-ray tube;**
- **the first flat faced tube ;**
- **the first 14″ rectangular tube ;**
- **the first 17″ rectangular tube ;**
- **the first 21″ rectangular tube ;**
- **the first electro-static tube.**



Research and development to anticipate and meet the changing demands of the radio and electronic industries are integrated with modern manufacturing techniques in the production of BRIMAR cathode-ray tubes.

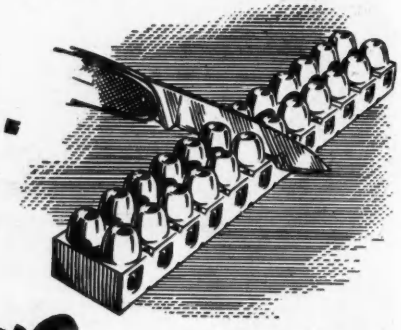
Consult BRIMAR *—the people who know—for your future equipment requirements.*

Standard Telephones and Cables Limited

FOOTSCRAY · SIDCUP · KENT. *Telephone:* FOOtscray 3333

You can bend it..

You can cut it..



—but just try and break THIS terminal block!

THIS component revels in "rough going"; no surfaces are too uneven. Corners and curves that would preclude the use of a rigid type, are just the conditions that show up the novel and useful features of this flexible terminal block. In addition, many of the difficulties experienced when using the rigid type of block are overcome, e.g., broken mouldings due to tightening of screws, lost terminal screws, and the difficulty of modifying to the required number of ways.

In the "Belling-Lee" design the terminal screws are captive, the heads being firmly gripped by the resilient P.V.C. moulding *and cannot be shaken or fall out, even when the block is mounted upside down*, or carelessly mishandled.

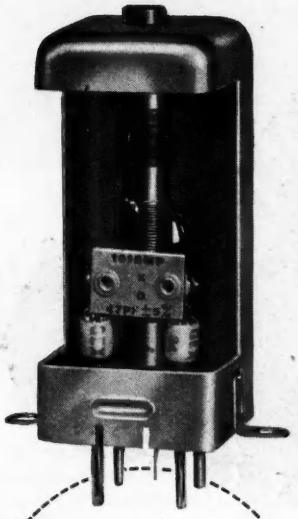
The component can be cut with an ordinary pocket knife into smaller groups of terminals as required, and for the purpose of fixing, holes are provided between each pair of terminals.

- ★ **Captive Terminal Screws**
- ★ **Flexible**
- ★ **Easily Sectionalised**
- ★ **Mechanically Shock-proof**
- ★ **Rating 5 amp. Up to 10 amp may be used at designer's discretion**
- ★ **12 Way**
- ★ **Overall size 5″ x .750″ x .625″ high. Holed centres spaced .425″**

Please write for Leaflet P.378/E.E.

BELLING & LEE LTD
GREAT CAMBRIDGE ROAD, ENFIELD, MIDDX., ENGLAND

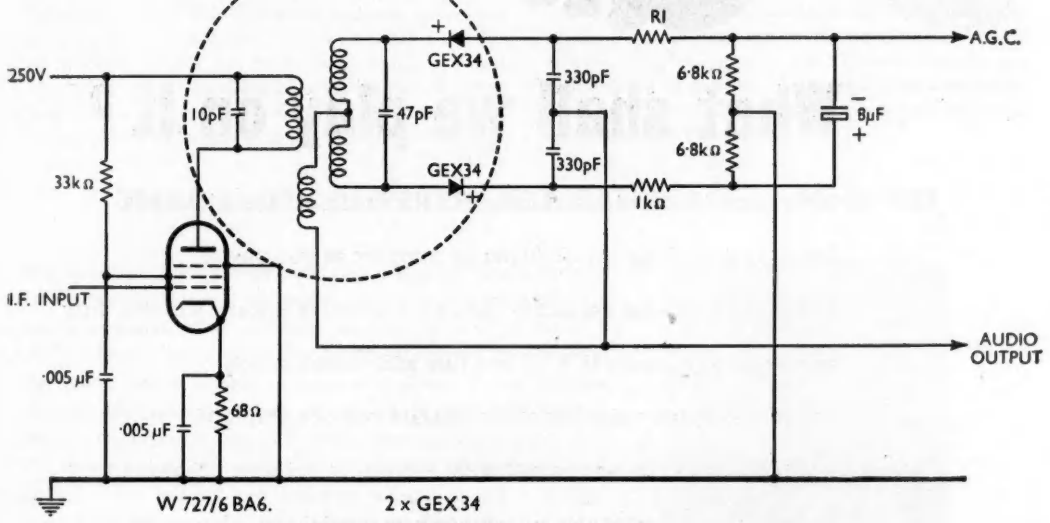
G.E.C. GERMANIUM DIODES



GEX 34 in the Ratio Detector

The Ratio Detector has been generally accepted as the most practical form of detector for receivers designed for the new High Quality F. M. Service to be inaugurated next year, since it obviates the need for a separate limiter stage.

The illustration shows the application of two GEX 34 in a typical ratio detector where full advantage has been taken of its small size by enclosing them in the I.F. transformer can. This construction reduces the risk of instability and eliminates the possibility of harmonic feed back via the heater leads.



ADJUST RI FOR MINIMUM A.M. OUTPUT

Transformer Design. Although the circuit shown above is conventional, an I.F. transformer designed for use with thermionic diodes is not necessarily the most suitable for germanium diodes. A suitable design of transformer has been evolved at The G.E.C. Research Laboratories, details of which are available on request.

Write to The Osram Valve and Electronics Department,

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, W.C.2.

What shall we play on it?

Our repertoire on the Austinlite Rotary is almost inexhaustible.
Choose a switching composition as complex as you please
and it is a practical certainty that an Austinlite Rotary will not only
handle it, but handle it with less fuss and complication
and in less space than any other method you can think of.

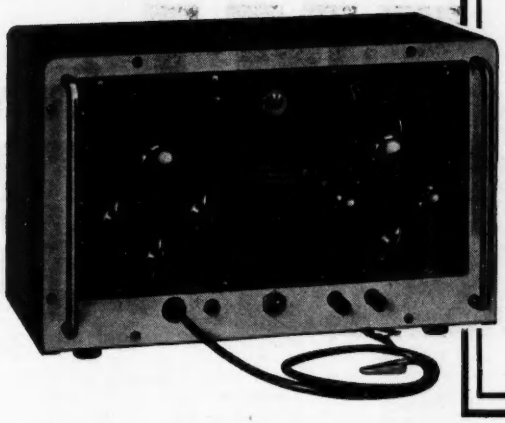
We can do anything you ask with Austinlite rotaries because every switch is built for its job, no matter how special the job may be.

Rotary switching is 'Simplified Switching'

ask *Austinlite* about it

AUSTINLITE LIMITED, LIGHTHOUSE WORKS, SMETHWICK 40, BIRMINGHAM

(A subsidiary of Stone-Chance Ltd., the makers of Sumo Pumps and Stone-Chance Lighthouses)



BE READY FOR TOMORROW — TODAY!

WITH THESE TWO *NEW* COSSOR INSTRUMENTS

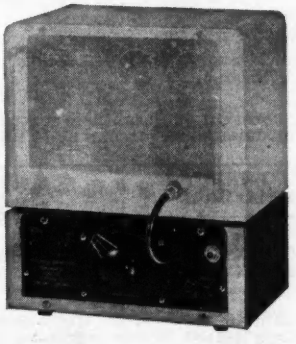
COSSOR Model 1322

Telecheck and Marker Generator for Bands I and III

Model 1322 — used in conjunction with a cathode ray oscillograph — provides equipment for the display, measurement and correct adjustment of RF and IF response curves of television receivers. This entirely new instrument comprises a swept oscillator covering the Television BANDS I and III (5-75 Mc/s. and 155-255 Mc/s.) and a frequency marker oscillator so that precise calibration of the oscillograph display may be made; accuracy of the frequency of the marker pips being verified by reference to an internal crystal. The alignment oscillator is set to the video carrier to which the receiver is tuned and the sweep (either 1 Mc/s. or 10 Mc/s.) is automatically derived from the time base voltage of the display oscillograph. The response of the "strip" under test to the frequency band applied is then presented on the screen of the cathode ray tube. The RF output of Model 1322 is available at 75 ohms and is adjustable from a maximum of 40 millivolts to a minimum of 10 microvolts through a coarse and fine attenuator.

TELECHECK CONVERTER FOR BAND III Model 1321

This adaptor provides owners of Model 1320 "Telecheck" with an extension of the frequency range of the original instrument into the BAND III television channel. Thus, alignment procedures adopted for BAND I RF/IF "strips" are available also for BAND III receivers. A selection of the desired BAND is made by means of a switch. Pattern generator facilities for picture time base linearity checks have been retained. Model 1321 Adaptor is designed for permanent attachment to the standard "Telecheck" providing a neat, light and compact unit. Mounting is effected by four screws and the inter-connecting wiring is carried in a single insulating sleeve.



COSSOR ELECTRONIC INSTRUMENTS

Write for illustrated leaflets about both these instruments :

OL.66

A. C. COSSOR LTD · INSTRUMENT DIVISION (Dept. 2) HIGHBURY GROVE · LONDON · N.5

Telephone: CANonbury 1234 (53 lines) *Telegrams: Cossor, Norphone, London* *Cables: Cossor, London*

THE NEW E·M·I 25 Mc/s OSCILLOSCOPE

For Research, Design, Production Testing and Servicing.

A new all-purpose wide range precision measuring oscilloscope based on a simple, economic and well tried design.

The WM.5. which is console (or 19″ rack) mounted, has provision for six additional sub-units which can be used individually or suitably combined to extend the performance of the oscilloscope to meet almost any requirement within the fields of:—High definition radar, Nucleonic investigation, Electronic computing, Television studio and transmitter equipment, H.V. Pulse test and general electronic measurement.

BASIC OSCILLOSCOPE—SPECIFICATION.

EMITRON CRT. TYPE 4EP1. Post Deflect Accel. 10KV max.
Diameter 10 cms. Side arm plate connections.
Sensitivity — X Plates. 0.1 mm/V — 1.0 mm/V (A_2 5KV — 0.5 KV).
Y Plates. 0.174 mm/V — 1.74 mm/V (A_2 5KV — 0.5 KV).

TIME MEASUREMENT
100 milli-seconds — 10 milli-micro-seconds (±2½%) in 11 ranges.

VOLTAGE MEASUREMENT
500V — 100 mV (±2½%) in 7 ranges.
Extended to 10mV with suitable sub units.

VOLTAGE REFERENCE
Voltages can be measured relative to external circuit potentials up to ± 500 volts.

SWEEP SPEED RANGE
150 cms/microseconds (5×10^{-9} sec/cm) to 33 cms/sec. (3×10^{-3} sec/cm).

Z INPUT
10Vpp for beam cut off (brightness control normal).
Cathode modulation frequencies up to 100 Mc/s.

RATE PULSE OUTPUT
10Vpp repetition as time base (100 Kc/s — ½ c/s).
Rise time 0.15 microseconds.

SAWTOOTH OUTPUT
100Vpp repetition as time base (100 Kc/s — ½ c/s).

PHOTO SWEEP
Single sweep for photo recording of transients, subsequent few sweeps before blackout of tube give reference trace which can be preset to any voltage up to ± 500V D.C.

SWEEP DRIVE
Min of 0.1Vpp to trigger time base.

SWEEP & DRIVE CIRCUIT FEATURES
(*a*) Phase Selector—Ultimate trigger or sync potential selected from a positive or negative wavefront.
(*b*) Time Base—Recurrent or Triggered and delayed/undelayed.
(*c*) Delay period/sweep period ratio—
240 max. 1 min. (shortest time range).
24 max. 1 min. (longest time range).

DUAL INPUT AMPLIFIERS	BANDWIDTH	* SENSITIVITY (EHT.10KV)	* SENSITIVITY (EHT.1KV)
X { Gain X3	D.C.— 8 Mc/s.	0.33 mm/V.	3.3 mm/V.
X { Gain X17	D.C.— 6.5 Mc/s.	2 mm/v.	20 mm/V.
Y { Gain X6	D.C.—25 Mc/s.	1 mm/V.	10 mm/V.
Y { Gain X12	D.C.— 9 Mc/s.	2 mm/V.	20 mm/V.

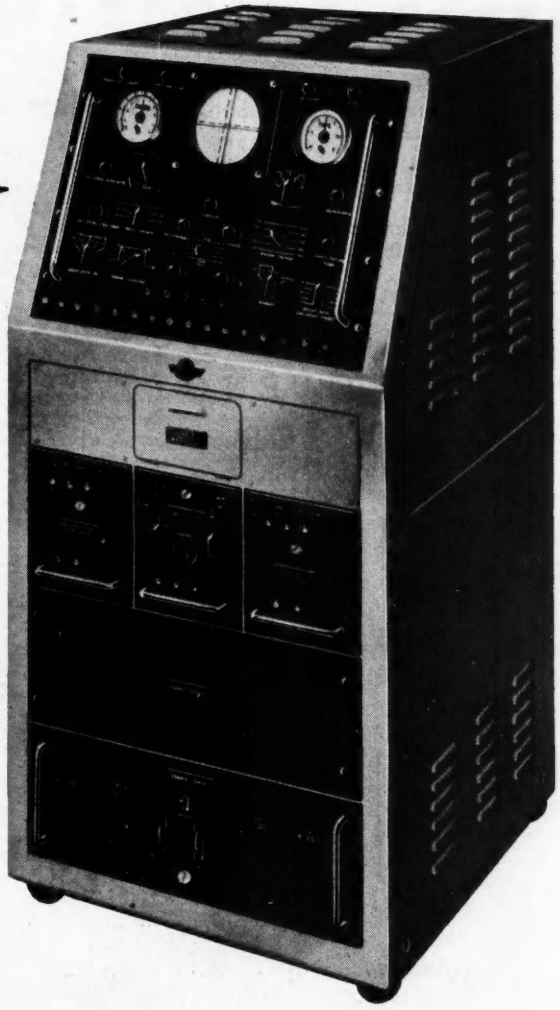
* Extended to 500mm/V with suitable sub unit.

E. M. I. FACTORIES LTD.

Head Office: HAYES, MIDDLESEX Telephone: SOUTHALL 2468

Telegrams & Cables : EMIFACTORY, LONDON

TYPE WM.5.



NEW FEATURES

1. New CRT—CONTINUOUSLY VARIABLE EHT. 1-10KV.
   Gives deflection sensitivity ratio control from 1 to 10 with unaltered frequency response.
   Enables selection of optimum operating condition for definition/writing speed/repetition rate and deflection sensitivity.
2. Y AMPLIFIER D.C.—25 Mc/s. (No Overshoot.)
   Differential input channels for signal time comparison and mixing.
3. LINEAR PRE-SWEEP SIGNAL COMPRESSION.
   Provides a linear pre-sweep vertically displaced from the normal sweep. Pre-sweep (duration 1 sec. —10 microseconds) can be varied from 1 to 240 times the normal sweep duration. Any series of complex waveforms can be displayed in compressed form on the pre-sweep and from this any small section can be identified and transferred to the normal sweep for display and measurement in expanded form.
4. DELAYED SWEEP:—
   Sweep may be delayed with respect to input trigger by 10 microseconds—1 sec. (in accordance with time range).
5. INSTANTANEOUS AC/DC VOLTAGE MEASUREMENT. (No calibration markers required.)
   Null indication C.R.T. Long scale voltmeter readings unaffected by amplifier or CRT non-linearity.
6. INSTANTANEOUS TIME MEASUREMENT. (No calibration markers required.)
   High accuracy time readings are meter presented.

WM.5. SUB UNITS.

INPUT UNIT TYPE 1—A special coupling unit for X,Y,Z, or sweep drive channels of the WM.5. High input impedance via cathode follower probe. Bandwidth - 40 Mc/s. 0.5 microseconds signal delay.

PRE-AMPLIFIER TYPE 3. Bandwidth - 40 Mc/s. Gain x 10. Input and Output Impedances - 300 ohms.

OTHER E·M·I EQUIPMENT

OSCILLOSCOPE TYPE WM.1.

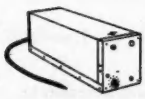
An inexpensive general purpose oscilloscope, incorporating the E.M.I. valve voltmeter measurement system. Voltage Measurement: ± 0.5 - ± 500 volts AC/DC. Instantaneous reading.

OSCILLOSCOPE TYPE WM.3B.

A compact general purpose portable oscilloscope with facilities for rapid precision time and voltage measurements. Voltage measurements by instantaneous metering system (± 10 mV - ± 500V. AC/DC.) No calibration markers required. This instrument can be supplied with trolley.

OSCILLOSCOPE TYPE 3794.TA.

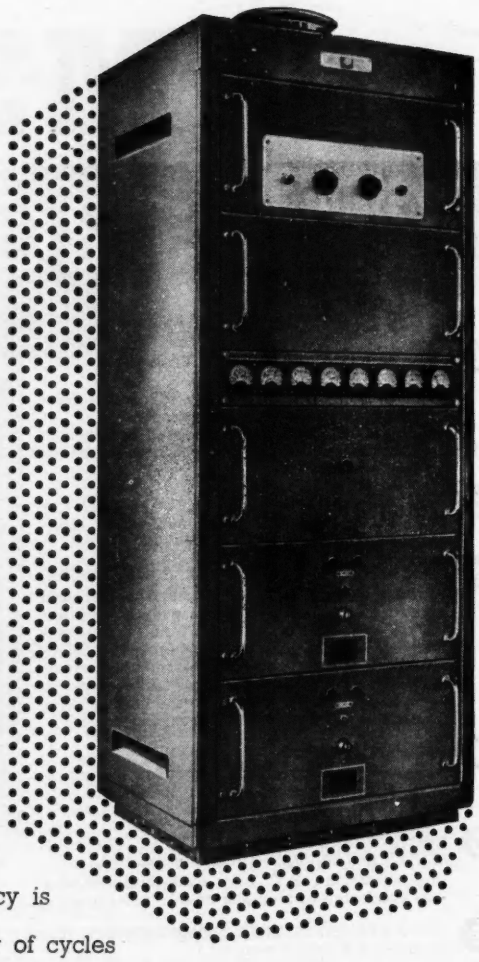
A trolley mounted multi-purpose precision measuring oscilloscope CRT, EHT-5kV. Voltage measurements by instantaneous metering system (± 50 mV to ± 500V. AC/DC.)



DISTRIBUTED AMPLIFIER TYPE 2B.

A unit designed for use with high speed oscilloscopes to provide amplification over a very wide frequency spectrum (50 c/s-100 Mc/s) at high output voltage levels.

AUTOMATIC FREQUENCY MONITOR (20 Mc/s)



Designed for the measurement of any frequency in the range 10 c/s to 20 Mc/s with a basic accuracy of ± 1 part in 10^6 ± 0.1, 1.0, or 10 c/s. Higher accuracies available if required. The unknown frequency is determined by counting the number of cycles that pass through a 'gate' open for a selectable time interval of 0.1, 1.0, or 10 seconds. The result is presented on eight panel mounted meters each scaled 0 to 9 and is in decimal notation. Full information available on request.

CINEMA-TELEVISION LIMITED

A Company within the J. Arthur Rank Organisation

WORSLEY BRIDGE ROAD · LONDON · SE26

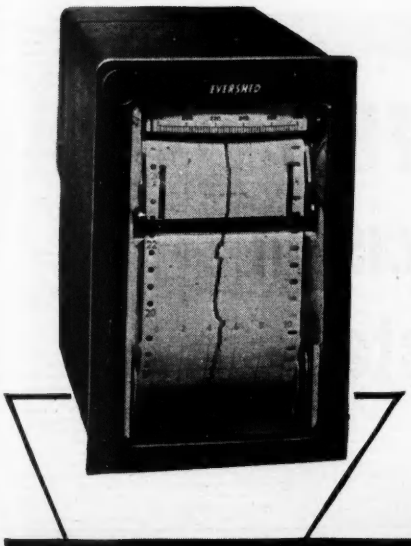
Telephone HITher Green 4600

SALES AND SERVICING AGENTS

F. C. Robinson & Partners Ltd., 287 Deansgate, Manchester, 3

Hawnt & Co., Ltd., 59 Moor St. Birmingham, 4

Atkins, Robertson & Whiteford Ltd. 100 Torrisdale Street, Glasgow, S.2



WATCHING BRIEF

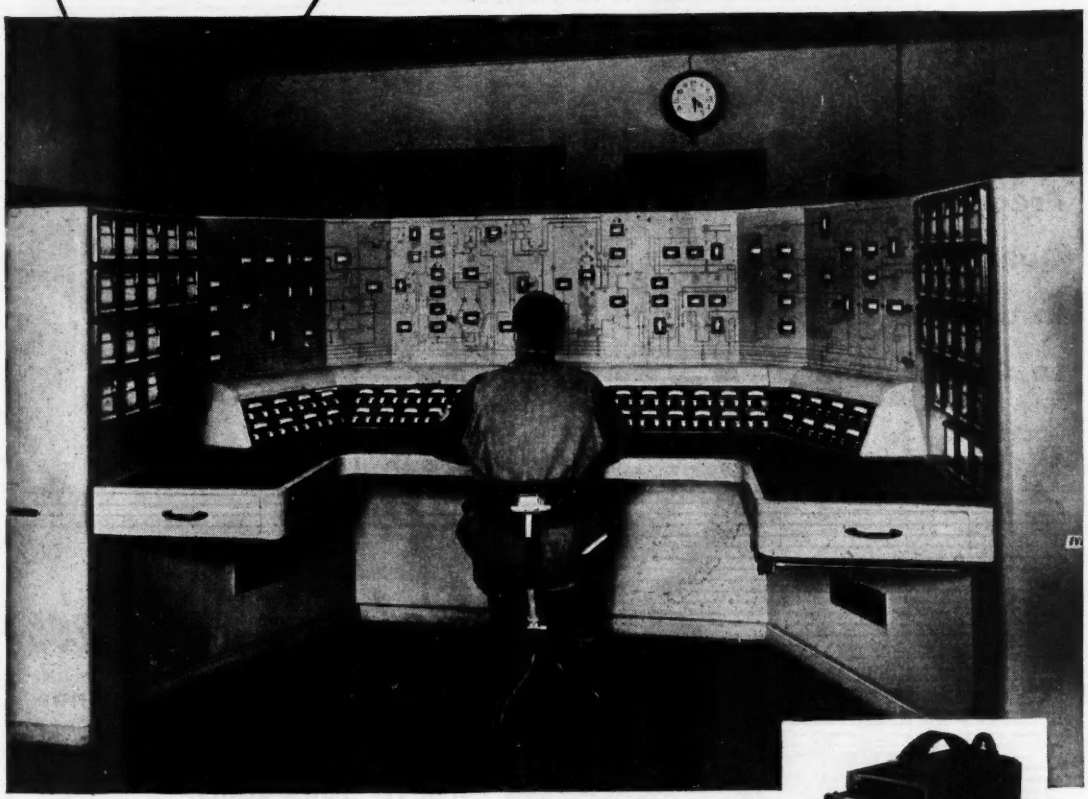
introducing the **new Miniature** Recorder by **EVERSHED**

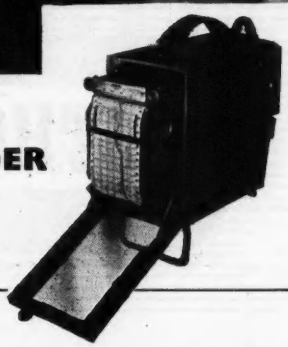
The modern trend towards miniaturisation in industrial control equipment has led to the design and development of the Evershed Miniature Recorder. Illustrated below is a Control Desk recently supplied to the Grangemouth Refinery of Scottish Oils Ltd., on which 38 recorders are fitted. They have also been supplied for the new Anglo-Iranian Refinery at Aden.

The Evershed Miniature Recorder has the maximum self-contained ranges of 500 v. or 10 amperes and will prove to be of great use to engineers and designers throughout industry. It is suitable for either flush or surface mounting or can, by the use of a leather sling, be used as a portable instrument.

Although compact, measuring only 4¼-inches wide by 6¼-inches high and 9-inches deep, the recorder will give a continuous record for one month. The movement which is of the moving coil type is calibrated to B.S. 90—1940 requirements.

FOR FULL DETAILS, WRITE FOR PUBLICATION EE 282





EVERSHED MINIATURE RECORDER

EVERSHED & VIGNOLES LTD

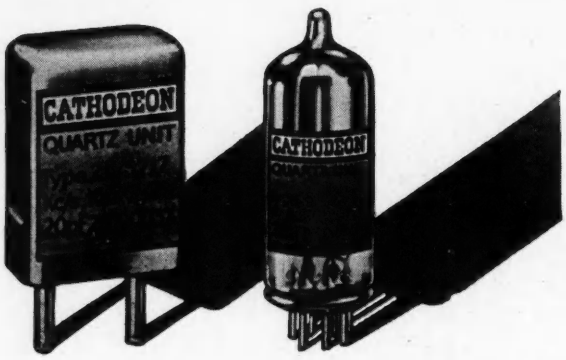
ACTON LANE WORKS CHISWICK LONDON W4

Telephone Chiswick 3670 *Telegrams Megger Chisk London* · *Cables Megger London*

a/184

For SPEEDY delivery of precision QUARTZ Crystals

Specialists in the manufacture of Frequency Control Quartz Crystals within the range 2,000 to 20,000 Kc/s



Special Urgency Service

Small urgent orders can now be executed within days, at competitive prices.
Ask for full details.

Tel. LINTON 223

CATHODEON

CRYSTALS LIMITED

LINTON · CAMBRIDGESHIRE

ENTHOVEN *Superspeed*-

for *'SIX STAR'* soldering . . .

Careful alloying and the incorporation of special fluxes contribute to its efficiency —but the stellate 6-CHANNEL CORE —secret of faultless fluxing—places ENTHOVEN SUPERSPEED in a class by itself.

★ **Continuous stellate core has 6 channels of activated rosin flux.**

★ **Solders difficult parts uniformly and quickly.**

★ **Fastest non-corrosive, solder-and-flux combination for industry.**

★ **Activator is rendered harmless by soldering heat.**

★ **Eliminates dry and high resistance joints often caused by incorrect fluxing.**

★ **Flux residue is hard, non-conductive, non-corrosive and non-hygroscopic.**

Designed as the result of exhaustive research into the properties of all kinds of single and multiple core systems, ENTHOVEN stellate 6-CHANNEL CORE combines all the advantages of both. It comprises, in effect, six distinct flux channels—all located close to the circumference of the solder tube and all connected with the main central channel.

When the heated solder metal collapses, the flux is released—not merely from the channel nearest the heat, but from all six channels simultaneously. Hence the quick, generous flow of precisely the right amount of activated rosin flux eliminates all possibility of dry or high resistance joints. Hence the name *SUPERSPEED* for the most efficient and reliable of all cored solders.

MANUFACTURED BY

ENTHOVEN

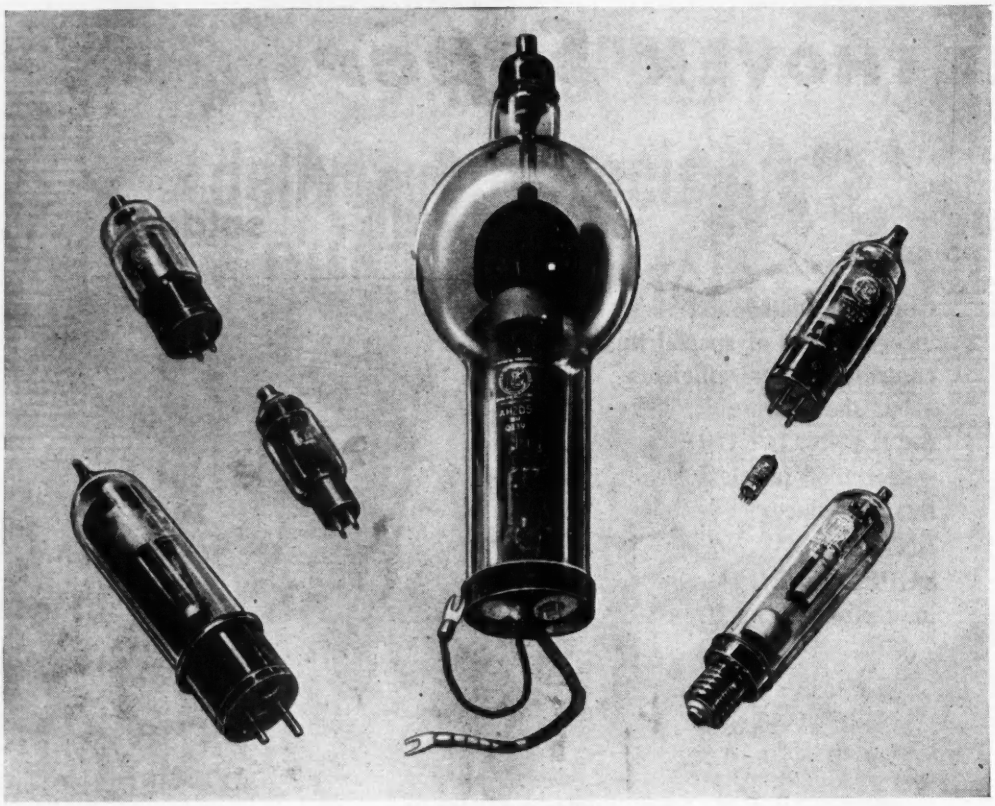
SOLDERS LIMITED

SUPERSPEED activated rosin-cored solder for general electrical, electronic and telecommunication work, and all standard uses. A.I.D. approved to M.O.S. Specification DTD 599. Complies with B.S.441, RCS 1000, and other current specifications issued by G.P.O. and other Government departments.

SUPERSPEED is available in a wide range of alloys and gauges. Samples, together with comprehensive literature, gladly sent on request.

ENTHOVEN SOLDERS LIMITED · 89 UPPER THAMES STREET · LONDON E.C.4. MANsion House 4533

POWER RECTIFIERS & THYRATRONS



POWER RECTIFIERS

	Type	Max Dimensions in m/m.		Filament		P.I. Voltage	Peak Anode Current	Mean Anode Current	3 Phase F.W. Output		British Services Number	American Equivalent
		Length	Dia.	Volts	Amps				D.C. Volts	Rect. Cur'c		
Mercury Vapour Filled	AH.200	456	133	2.5	40	16,000	8.0(a) 14.0(b)	2.0(a) 3.5(b)	15,000	5.5(a) 10.0(b)	CV 1628	—
	AH.201	179	42	2.5	5	11,000	1.0	0.25	10,000	0.75	—	—
	AH.205	505	194	5.0	30	22,000	40	10	21,000	30.0	CV 2673	857B
	AH.211 AFH.220 (c)	314	97	2.5	30	16,000	8.0	2.0	15,000	6.0	CV 532	—
	AH.213	456	133	5.0	19	16,000	8.0(a) 14.0(b)	2.0(a) 3.5(b)	15,000	5.5(a) 10.0(b)	—	869B
	AH.217	220	63	5.0	7.5	11,000	5.0	1.25	10,000	3.6	—	872A
	AH.221	270	63	4.0	11	11,000	4.7	1.2	10,000	3.6	CV 5	—
Xenon Filled	AX.22ϕ	157	53	2.5	5.0	10,000 5,000	1.0 2.0	0.25 0.5	9,600 4,800	0.75 1.5	CV 1835	3B28
	AX.228	270	63	4.0	11.0	11,000	5.0	1.25	10,000	3.6	—	—
	AX.230	216	59	5.0	7.1	10,000	5.0	1.25	9,600	3.75	CV 2518	4B32

(a) Filament Voltage in phase with anode current.
(b) Filament Voltage 60°—120° out of phase with anode current.
(c) AFH.220 is grid controlled with positive characteristics.

THYRATRONS

	Type	Max Dimensions in m/m.		Filament		P.I. Voltage	Peak Forward Volts	Peak Current	Mean Current	Tube Drop	Peak Power Level (a)	British Services Number	American Equivalent
		Length	Dia.	Volts	Amps								
Xenon Filled	AFX.212	54	19	6.3	0.25	350	350	0.11	0.025	16	—	CV 1949	6D4
	AFX.203	176	57	2.5	4.0	390	280	1.7	0.40	11	—	CV 2868	C1A
Hydrogen Filled	FX.215	286	97	2.5	27.5	16,000	16,000	200	0.20	100	2.0×10^9	CV 2203	—
	FX.219	222	65	6.3	10.6	16,000	16,000	350	0.20	100	3.2×10^9	CV 2520	5C22
	FX.225	178	65	6.3	6.1	8,000	8,000	90	0.10	100	2.0×10^9	CV 1787	4C35
	FX.227	132	40	6.3	2.25	3,000	3,000	35	0.045	100	0.3×10^9	CV 372	3C45

Note (a) Product of Peak forward Voltage, Peak current and pulse repetition frequency.

ENGLISH ELECTRIC VALVE COMPANY LIMITED · WATERHOUSE LANE · CHELMSFORD · ESSEX

FERRANTI

T-R CELLS

For incorporation in military and marine radar equipment, a comprehensive range of 3 cm. and 10 cm. T-R Cells are available.

TTR.31 A tunable high Q T.R. Cell for use with ¾" diameter circular waveguide.
Frequency Range : 9100-9900 Mc/s
Band Width : 5 Mc/s
Handling Power : 50 kW. peak

TTR.31MR and TTR.31MC Tunable medium Q T.R. Cells for use with standard American waveguide (TTR.31MR) or ¾" diameter circular waveguide (TTR.31MC)
Frequency Range : 9100-9900 Mc/s
Band Width : 25 Mc/s
Handling Power : 50 kW. peak

Full details of these and other T.R. Cells from our range will be supplied on request.

WRITE FOR :—
LIST ES/V/1—T.R. CELLS
LIST ES/T/6—'PENTLAND' SERIES COMPONENTS

'PENTLAND' SERIES RESIN CAST COMPONENTS

The Ferranti 'Pentland' series of components includes Power Transformers and Chokes, Signal and Pulse Transformers and Delay Networks.

These units are cast in a solid block of synthetic resin which replaces the oil-filled container previously considered essential for high quality components and below are listed some of the notable advantages conferred by this technique :

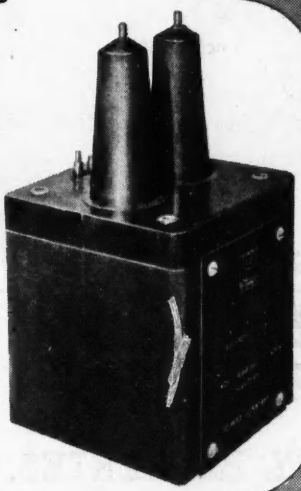
Extreme robustness combined with minimum weight and volume.

Complete hermetic sealing.

Fire risk greatly reduced.

Reliable operation through a wide range of ambient temperatures and climatic conditions.

'Pentland' series components are designed to customers' specification and full details will be supplied on request.

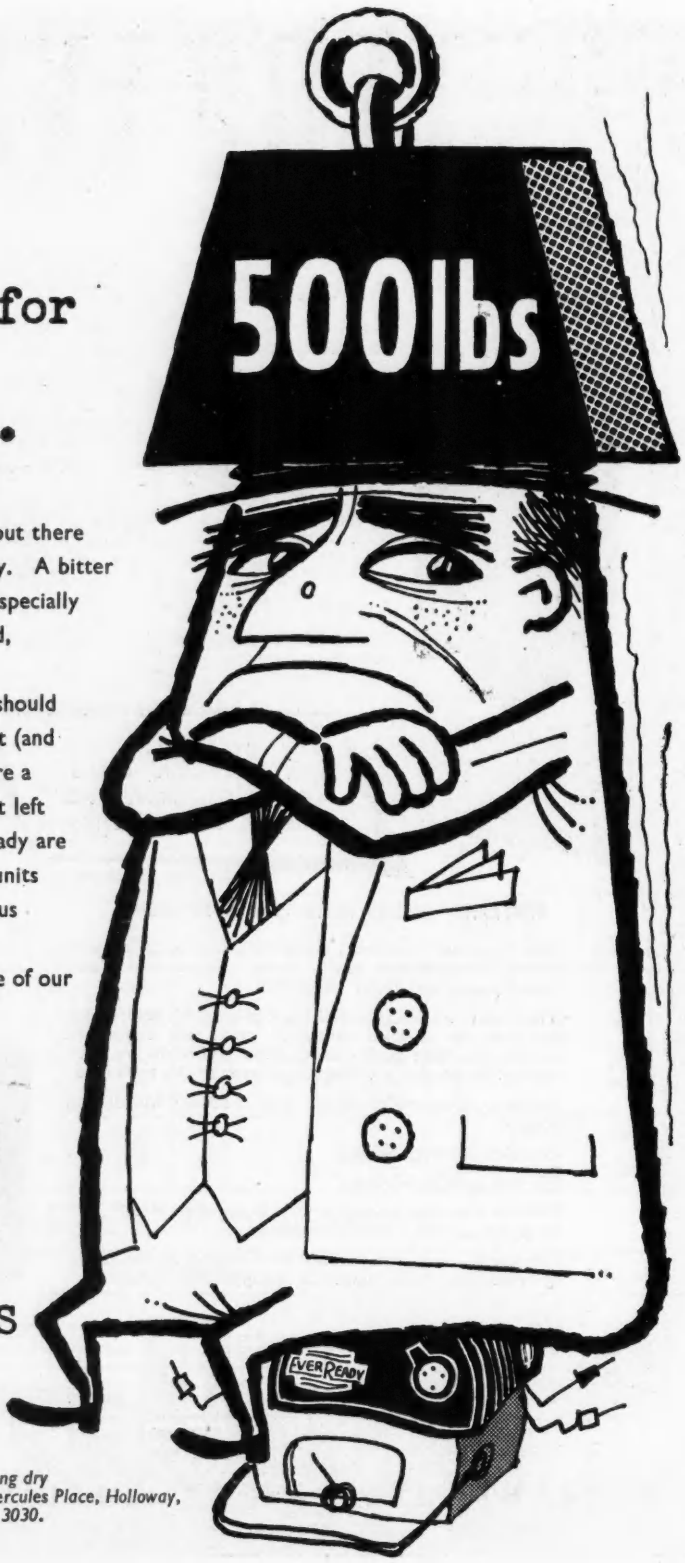


FERRANTI

FERRANTI LTD FERRY ROAD EDINBURGH 5

ES/T4

A headache for somebody ...



It was a great little portable — but there just wasn't room for the battery. A bitter blow for the designer. Unless specially designed batteries were ordered, he would have to start again. Designers of battery radio sets should note this dilemma. Time, effort (and money) are wasted if you prepare a design and then find you haven't left room for the battery. Ever Ready are always able to make up special units but it's so much simpler to call us in early so that your set is designed, if possible, to take one of our many standard batteries.

EVER READY
REGD TRADE MARK

DRY BATTERIES FOR RADIOS

* *If you have a design problem involving dry batteries, get in touch with us at Hercules Place, Holloway, London, N.7 Telephone : ARChway 3030.*

FOSTER

offers

NEW HIGH STANDARD IN STABILISED A.C. POWER SOURCES

ELECTRONICALLY CONTROLLED CONSTANT VOLTAGE SET TYPE VR/ECV

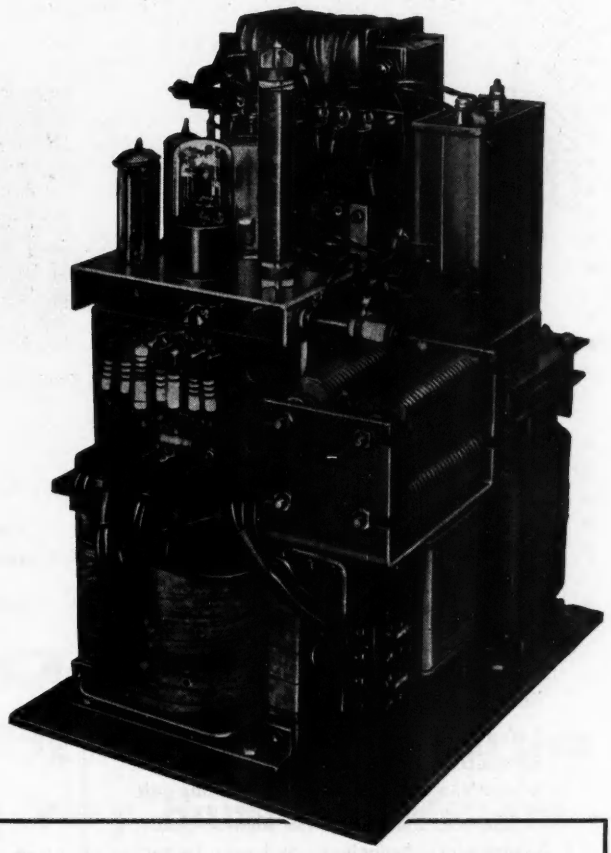
The problem of stabilising an A.C. source of supply for the varying needs of industry has up to now been only partially solved. There are several types of saturated core constant voltage transformers which satisfy some of the conditions, but these generally are frequency dependent and any additional compensating circuit for this feature renders the equipment load dependent. Also there are the electro-mechanical type regulators depending on the operation of a transformer tap-changing mechanism by an automatically controlled motor, the disadvantages of such circuits are the slow speed of response and the inconvenience of moving parts.

There are many applications in industry and communications where the disadvantages of the above circuits render them unsuitable. Such equipment as radar, photographic printing, spectrometers, electronic circuits and instruments containing illumination references call for a high degree of constancy of the mains supply under all operating conditions.

We have therefore developed a piece of static equipment capable of supplying a variable load with constant voltage irrespective of mains frequency and voltage changes. The equipment has been designed so that the output voltage has a low harmonic content, but in any case the R.M.S. value of voltage is maintained constant.

A potentiometer connected transductor circuit is employed while the control winding of the transductor is supplied from a voltage sensitive circuit incorporating a saturated diode.

A 1000 VA unit is now under development.



The following specification gives the salient features of the performance of the set

Mains frequency	**40-60 cycles/sec.**
Load	**Zero to 500 VA maximum.**
Speed of response	**5 cycles.**
Input Voltage	195-260 volts.
Output Voltage	230 volts ± 0.25%.
Regulation	0.5% No load — Full load.
Harmonic content of load voltage	Not greater than 8%.
Physical size	10½" x 12½" x 15" high.
In sheet steel case	Weight 52 lbs.

FOSTER TRANSFORMERS LTD., SOUTH WIMBLEDON, LONDON, S.W.19

A 'LANCASHIRE DYNAMO HOLDINGS' COMPANY

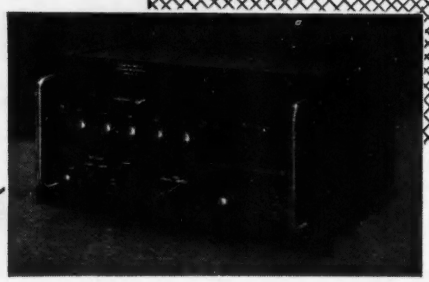
VR/5

. . . the originators of the 'Dekatron' now make generally available the

Type 1221B Dekatron Scaling Unit

as previously supplied exclusively to

A.E.R.E. (Harwell)



Production Models (immediate delivery) **from £90**

In this all-cold-cathode unit, developed in conjunction with A.E.R.E. (Harwell), the maximum count of 10^5 is displayed on five Ericsson Dekatron tubes.

The instrument is designed primarily for use with a G.M. counter and A.E.R.E. Type 1014A probe unit, although any input pulses of appropriate amplitude and duration can be counted.

A plug-in timing unit can be supplied; alternatively, a relay unit is available for use with an A.E.R.E. Type 1003 timing unit.

The instrument uses the highest quality components throughout, and may be rack mounted or used on the bench without modification.

SPECIFICATION

Counting Rate	2000 p.p.s. maximum.
Maximum Count	Normal 105. Output pulse at 10^4 for operating additional units.
Operating Pulse	Positive or negative. Minimum amplitude 10v peak. Minimum duration 25 micro-secs. at 50% peak amplitude.
Operation	"Off-Count" key controls input. Push button resets all decades to zero.
Power Supplies	200-250v +5% −10% 50 cps, or 110-125v +5% −10% 60 cps. Consumption approx. 35W. Provision is made for supplying LT and HT for 1014A Probe Unit, together with 760v 50 cps. for operation of external EHT unit.
Finish	Black, to A.E.R.E. specification.
Dimensions	Panel 19" × 8.3/4". Depth 12".
Weight	35 lb.

ELECTRONIC T E L NUCLEONIC INSTRUMENTS

Complete details of Scale. 1221B, accessories. 'ADD-ON' equipment and other instruments available from

ERICSSON TELEPHONES LIMITED

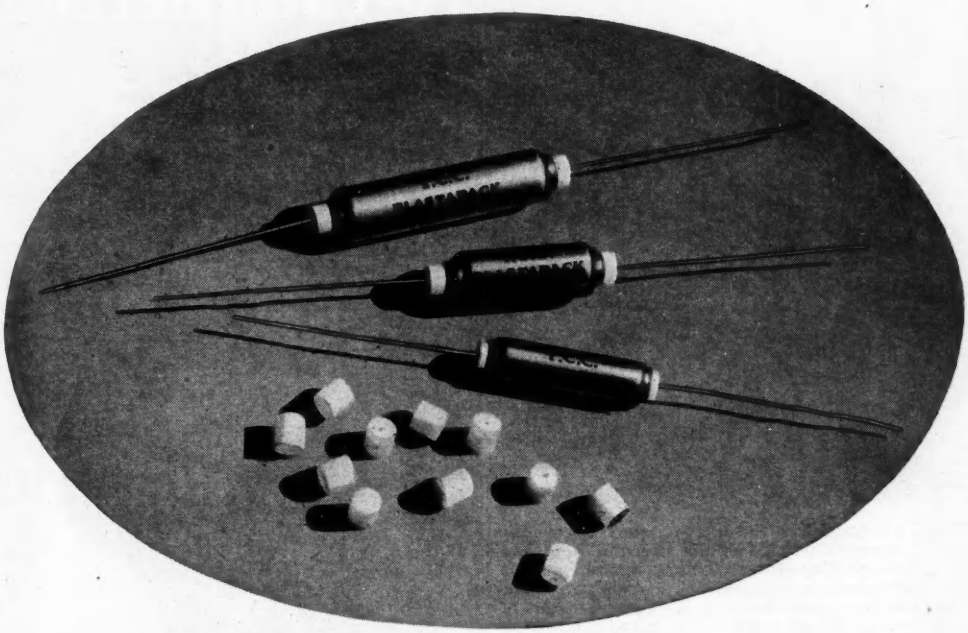
WORKS: BEESTON, NOTTINGHAM

Head Office: **22 LINCOLN'S INN FIELDS, LONDON W.C.2.** *Tel: HOLborn 6936*

(E20)

FROM 60 TO 10^9 C.P.S.!

AND FROM −80°C TO 250°C



'FLUON' is used by The Telegraph Condenser Co. Ltd., London, to seal the ends of their tubular condensers, T.C.C. Patent Nos. 698607 and 698608—which will give completely reliable service even under hot, humid conditions.

'FLUON' *

holds its outstanding electrical properties even under very humid conditions

Power Factor 0.0001
Dielectric Constant 2.0
Dielectric Strength 1,500 to 1,800 volts/mil on .005 in. sheet
Water Absorption NIL
Non-Tracking

**'FLUON' is the registered trade mark of the polytetrafluorethylene manufactured by I.C.I.*

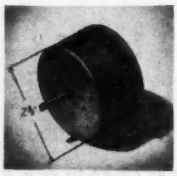
Please ask for full technical data from:
IMPERIAL CHEMICAL INDUSTRIES LTD., LONDON, S.W.1

P.569

TOROIDAL POTENTIOMETERS

If you would like full details of our range of Toroidal High Precision, Helical and Heavy Duty Ceramic Potentiometers, send for our newly-published Catalogue No. 102.

Ceramic Insulation only — and approved for Tropical conditions. Complete Ceramic Rings for strength. Approved by all Government Departments. Also precision Toroidal-wound Potentiometers (including 360° of winding with up to eight tapping points) and Helical wound Potentiometers of 3600° of winding. All are available with sealed spindles and glass or ceramic terminal seats.



TOROIDAL PRECISION POTENTIOMETERS
WITH TAPPING POINTS
TYPES B and C

SPECIFICATIONS

TYPE B (With tappings and Ball Races)

RATING—5 Watts normal.
RESISTANCE RANGE—500 ohms to 30,000 ohms.
WINDING—Nickel/Copper and Nickel/Chrome Wires.
ANGLE OF ROTATION—Continuous rotation, no stops.
ANGLE OF WINDING—360°.
RESISTANCE TOLERANCE—±5% before joining, or as specified.
TAPPINGS—Two, three or four, or as specified.
TYPE OF BEARINGS—Ball Races.
LINEAR ACCURACY—Within 0.25% on the higher resistance values.
OPERATING TORQUE—0.5 in./oz. (36 gram./cm.).
MOUNTING—3 hole fixing.

TYPE C (With tappings and plain bearings)

Type C Potentiometer is similar to the above except as follows :—
MOUNTING—Single hole fixing ⅜ in. diameter ×26 T.P.I. With panel locating pin.
TYPE OF BEARINGS—Long plain bearings.
OPERATING TORQUE—2 in./ozs. (144 gram./cm.).

Thanks to extensive re-organisation, we can now give good delivery of all types of potentiometers

P · X · FOX LTD · HAWKSWORTH RD · HORSFORTH · YORKSHIRE

Telephone: Horsforth 2831/2 *Telegrams: Toroidal, Leeds*

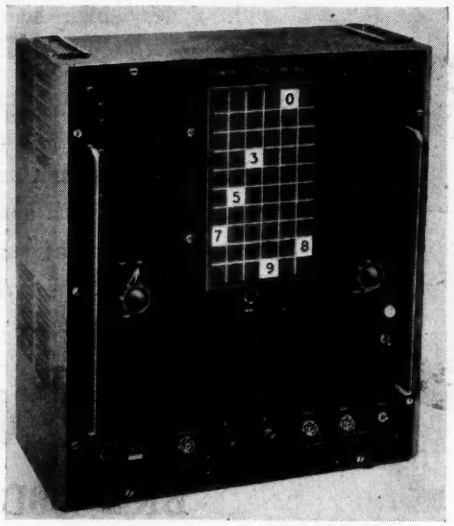
P·X·F

paf 2945

Announcing the NEW

AIRMEC *High-Speed*

ELECTRONIC COUNTER



COUNTING SPEED :

Maximum—1 million per second.
Minimum—No lower limit.

COUNTING RANGE :

9,999 million.

COUNTING DISPLAY :

Counts up to 999,999 are recorded on a brilliant display employing 6V 2W lamps behind ¾ in. square numbered windows. A four figure electro-mechanical counter extends the range to 9,999 million.

INPUT WAVEFORM :

Sinusoidal or pulse of any waveform recurrent or random, between 1.5 and 50V peak amplitude.

THE COUNTER TYPE 865 operates on electrical inputs of any waveform at speeds up to 1 million per second, and records the total count on a direct reading decimal display of exceptional brilliance and clarity.

Resetting the counter to zero is accomplished either by operation of the reset switch or by externally closing a circuit. Since both gating and resetting operations can be carried out externally, the instrument may be employed in conjunction with suitable auxiliary equipment for making time, speed and frequency measurements.

Write now for full details to :—

AIRMEC LIMITED

HIGH WYCOMBE BUCKINGHAMSHIRE ENGLAND

Cables : Airmec, High Wycombe
Tel : High Wycombe 2060

An outstanding general purpose communication receiver

Justly acclaimed as Britain's finest post-war communication receiver the BRT 400 D is in widespread use by Military, Post and Telegraph and Broadcasting authorities throughout the world.

Combining first-class performance with a wide range of facilities, the BRT 400 D is equally suitable for both narrow-band telegraphy and wide-band telephony reception—with a very high standard of reliability.

It is available in either cabinet or rack mounting form, with a 500 kc/s crystal calibration unit as an optional extra. Normal operation is from an A.C. mains supply: an auxiliary power unit is available for 12 volt battery operation.

G.E.C.

BRT 400D

SHORT SPECIFICATION

BAND COVERAGE

0.150—0.385 Mc/s } in 6 bands
0.510—30.0 Mc/s }

SENSITIVITY

Better than 1.0 μV for 1.5 watts output, over the whole band.

SIGNAL/NOISE RATIO

Standard input for 20 db:—

1.3—30.0 Mc/s	...	...	... < 7.0 μV
0.150—1.3 Mc/s	...	...	... < 10.0 μV

SELECTIVITY

Six switched bandwidths:—

0.5 kc/s	1.0 kc/s	2.0 kc/s
5.5 kc/s	9.0 kc/s	13.0 kc/s

OVERALL FIDELITY

Less than 2 db down at 50 c/s
Less than 6 db down at 5,500 c/s

A.G.C. CHARACTERISTICS

Output constant within 3 db for 100 db change in signal input.

OUTPUT CIRCUITS

At 2.5 or 15 ohms	...	...	...	2.5 watts
At 120 ohms	...	...	...	0.05 watts
At 600 ohms	...	...	...	0.2 watts

POWER SUPPLY

95—130 and 195—250 volts, 40/80 c/s. Also from 12 volt battery, using BRT 401 auxiliary power unit.

For the full specification please send for a copy of publication BC2084.

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

the short answer

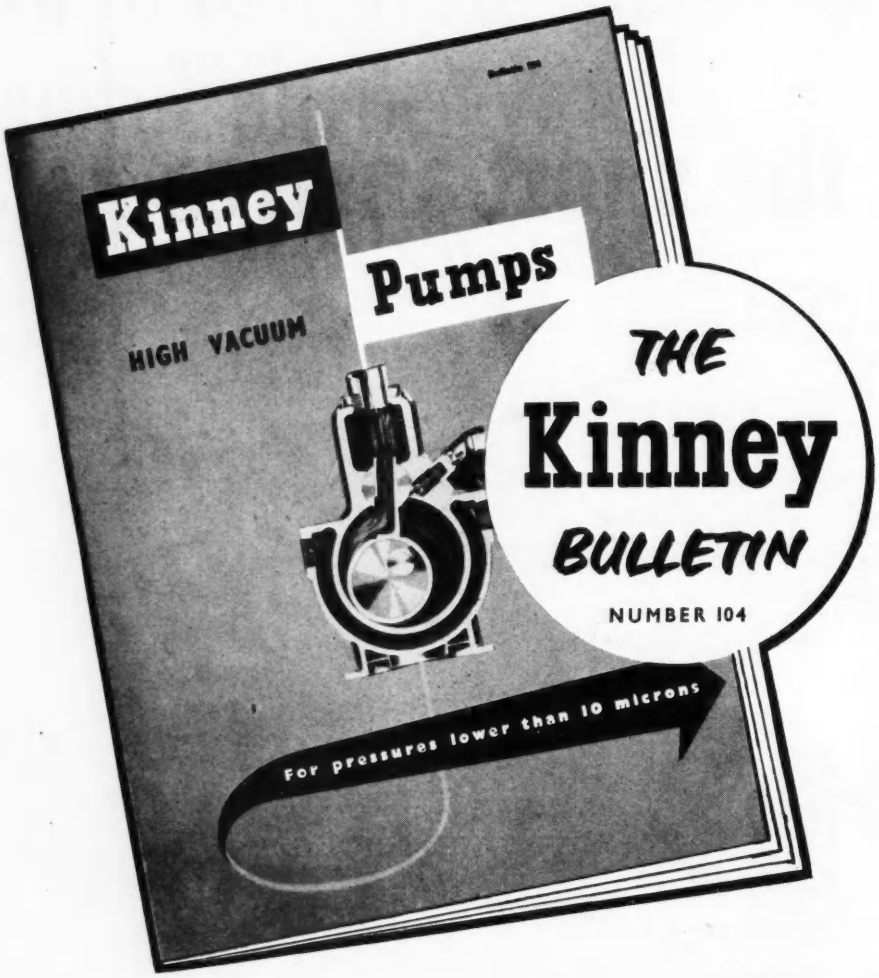
Neither we
nor our licensees
infringe
any competitor's
patents.

PHOTO PRINTED CIRCUITS LTD.

GUILDFORD ROAD · BISLEY · SURREY

Telephone: BROOKWOOD 2200

AVAILABLE TO YOU NOW FREE!



6 PAGES OF SOUND TECHNICAL ADVICE ABOUT KINNEY VACUUM PUMPS

If you manufacture products like electric lamps, coated lenses, mirrors, C.R. tubes, foodstuffs, drugs and coated foils, then Bulletin 104 has been printed for you. Here is a wealth of detail describing and illustrating Kinney High Vacuum Pumps—how they work, quoting dimensions, speeds and performance curves. Everything, in short, to demonstrate how indispensable Kinney Pumps are for up to date production processing. Bulletin 104 cannot fail to be of interest and (we sincerely believe!) profit. Pin this ad. to your note heading. We'll be glad to mail you by return.

GENERAL ENGINEERING CO. (RADCLIFFE) LTD.

Station Works, Bury Road, Radcliffe, Lancs.

Telephone: RADcliffe 2291 (3 lines) **Telegrams: "General" Radcliffe**

London Office: 3rd Floor, 9 Victoria Street, London, S.W.1
Telephone: Abbey 5278

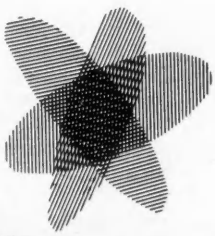
RCA

COLOUR TELEVISION

$100,000,000 is a lot of money by any standards!

This is the amount which RCA has devoted to television research and development and from which the RCA compatible colour television system in the United States of America has emerged.

IN INTRODUCING COLOUR, RCA has developed many specialised items of equipment which can be made available to manufacturers preparing for the introduction of a British colour television service.



Colour Image Orthicons
Flying Spot Scanners
Colour Multiplier Phototubes
Tri-Colour Kinescopes, 15" and 21"
Colour TV Test Equipment
Etc. Etc.

RCA

Enquiries to :

RCA PHOTOPHONE LTD.

An Associate Company of the Radio Corporation of America

36 WOODSTOCK GROVE, LONDON, W.12.

ULTRA SARAH is a complete system providing means whereby the location of wrecked personnel may be achieved with speed and certainty. Its use of powerful radio signals permits economical search from both the surface of the sea and the air. The system provides positive location of any number of persons even in conditions of total darkness or fog.

To match the miniature technique which Ultra designers adopted for SARAH, this compact Leocast Transformer was specially 'tailored' by Gresham engineers, who virtually succeeded in 'getting a quart into a pint pot' retaining, of course, all the reliability which is inherent in Gresham Transformers.

To Every Transformer Problem
There is a GRESHAM *Answer*

HANWORTH **GRESHAM** MIDDLESEX
TRANSFORMERS LTD

BRITAIN'S LARGEST INDEPENDENT TRANSFORMER MAKERS

Two new GLASS FIBRE LAMINATES with a tremendous range of uses!

RILGLAZE "MF"

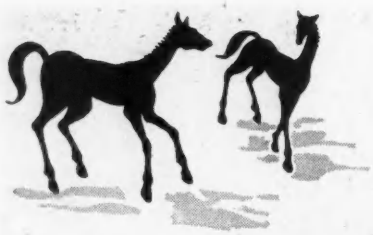
An inexpensive laminate, *fireproof*, with good mechanical properties.

RILGLAZE "S"

A general purpose *Insulating Material*, with good machining and punching properties.

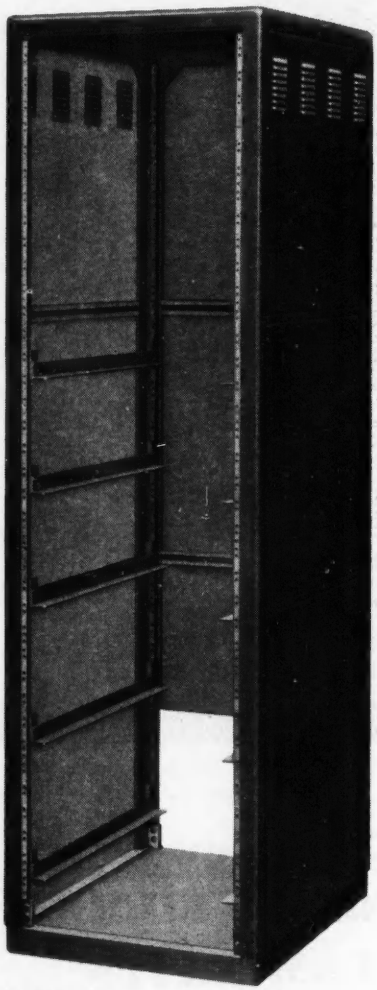
Write for specimens and quotations

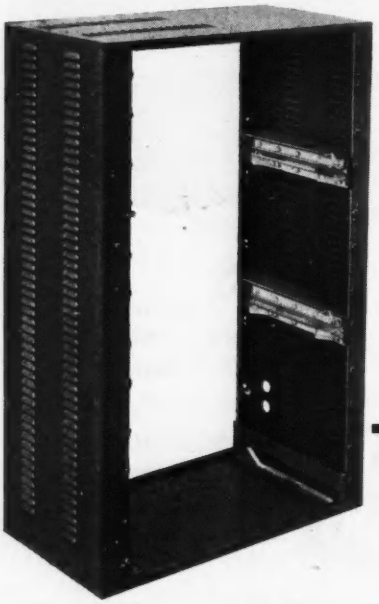
RUBBER IMPROVEMENT LTD., WELLINGBOROUGH, NORTHANTS · Tel: Wellingborough 2218 & 2286



TWO MORE THOROUGHBREDS

. . . from the rapidly expanding list of special Electronic Cabinets and Racks that we are producing to the requirements of our customers. Supreme in design, craftsmanship and finish, they are meeting with high praise wherever they are supplied. May we co-operate with your technicians in the production of similar cabinets to meet your own particular needs ?



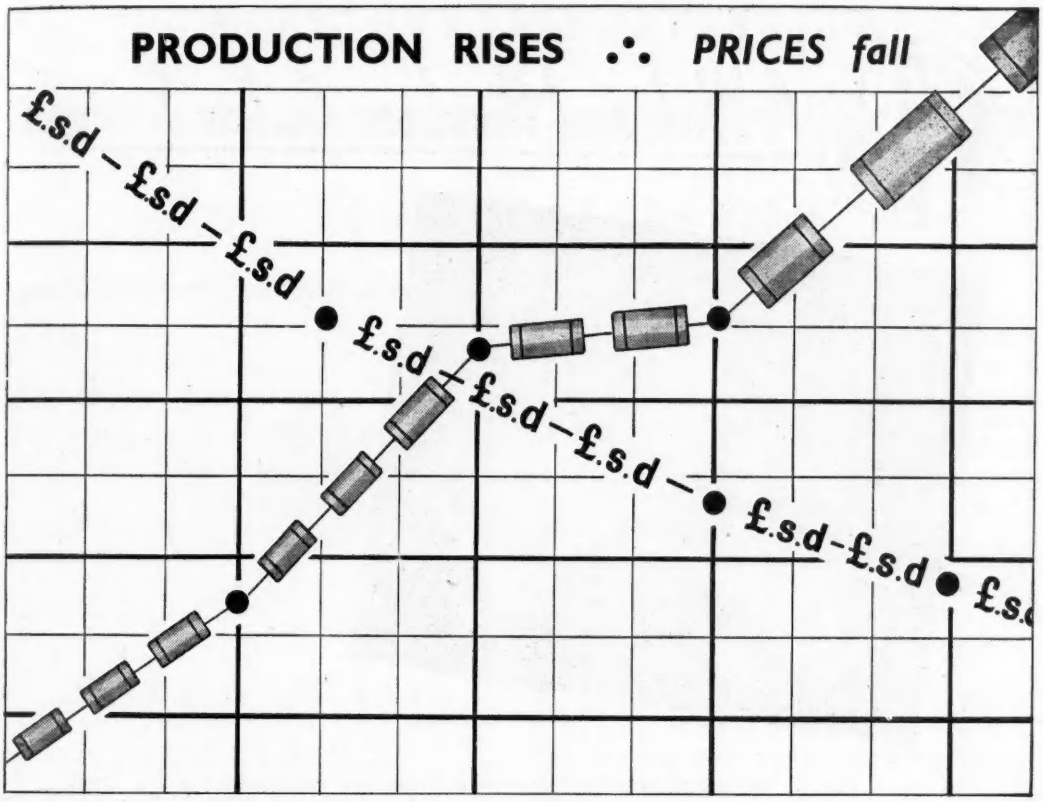


Please send for the H. & H. Catalogue of Electronic Instrument Cabinets, Racks and Cases.

Hassett & Harper Ltd

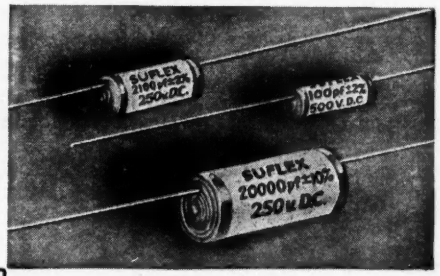
REGENT PLACE · BIRMINGHAM . 1
***Telephone :* CENtral 6418 (4 lines)**
***LONDON :* 140 PARK LANE · W.1**
***Telephone :* MAYfair 9651 (3 lines)**

CONTRACTORS TO GOVERNMENT DEPARTMENTS



SUFLEX POLYSTYRENE CAPACITORS

SUFLEX POLYSTYRENE CAPACITORS, because of their LOW DIELECTRIC LOSS and SMALL SIZE are admirably suited for use in I.F. transformers, padded circuits and wave-filters. Their uniquely high insulation resistance and low dielectric absorption make them indispensable in computors, nucleonic and medical equipment.



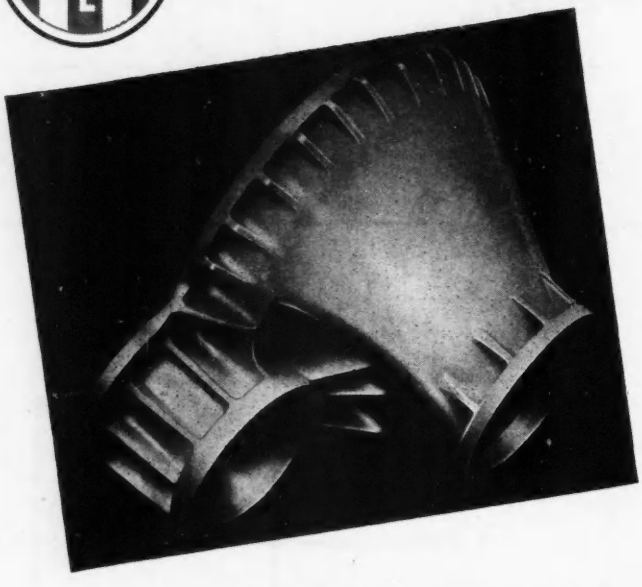
* The capacitors shown here are actual size

SUFLEX *Limited*
LONDON

CAPACITIES :	5 pf. to 0.5 mfd.
TOLERANCE :	20% to 1%
VOLTAGES :	250v. to 750v. D.C.
HS Type :	for general use.
HSA Type :	with additional sealing for use in exceptional humidity conditions.

35 BAKER STREET, LONDON, W.1. *Telephone :* WELbeck 0791

A Wide and Handsome Casting Service



Casting in Aluminium Alloy
(approx. weight 208 lbs.)

C and L Hill LTD would welcome your enquiries for Non-Ferrous Sand Castings, Brass, Naval Brass, Brazing Metal, Gunmetal, Phosphor Bronze, Aluminium Bronze, High Tensile Manganese Bronze, High Conductivity Copper, " Hilchil " Chill Cast Phosphor Bronze Bars, Cored and Solid. Sand Castings in all Aluminium Alloys, including Heat-treated Alloys, Aluminium Alloy Gravity Die Castings.

Hill facilities include

Wood and Metal Pattern Shop. Fully Approved Laboratory and Test House with Inspection Organisation. Facilities for Radiology. Specialists in Development and Quantity Production of Castings for Radar.

Design your Castings for SHELL MOULDING and save Machine Shop costs.

MEMBER OF THE OWEN ORGANISATION

You can support the B.R.M. through the O.R.M.A. (Owen Racing Motor Association) Members £1. 1. 0 per annum. Associate Members 5/-. Car Badge (full members only) £1.10. 0 extra. Full details from : THE SECRETARY, ORMA, KENT HOUSE, MARKET PLACE, OXFORD CIRCUS, LONDON W.1. Tele : Museum 8901-6

C.&L.HILL LTD

Stringes Lane, Willenhall, S. Staffs.

Tel : Willenhall 227 (4 *lines*) *Grams : Hill* 227 *Willenhall*

Branch Works : Wednesfield Road, Willenhall.

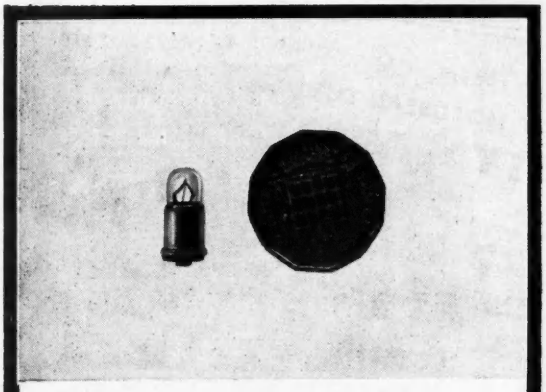
Both our Foundries are available for Prototype Work.

WhiteAd 3072 b

THORN CONTRIBUTIONS TO

space & weight saving

IN EQUIPMENT DESIGN

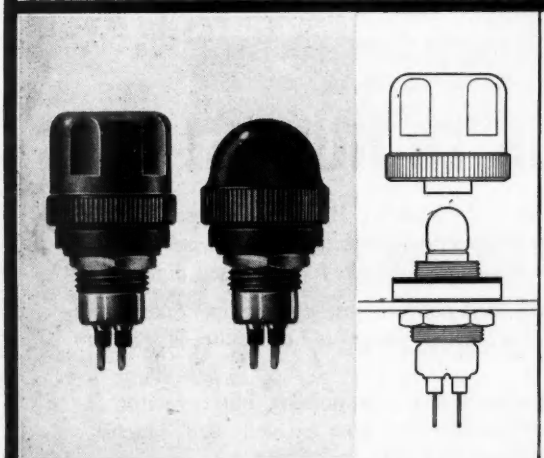


ATLAS MIDGET PANEL BULB Overall length: 14.6 mm. Bulb diameter: 6.3 mm. Rating: 28v., 1 watt, 0.04 amp. Also available in 12v., 6v. R.A.E. and S.R.D.E. type approval. Flanged cap and single centre contact for easy replacement.

The need for saving space and weight in modern electronic and panel control equipment is an ever present problem. The Atlas Midget panel bulb was designed with these difficulties particularly in mind. Tiny in size, simply and robustly constructed, its success is confirmed by type approval from the R.A.E., Farnborough, and S.R.D.E., Christchurch.

The development of the Atlas Midget panel bulb made possible the production of the Thorn Miniature Sealed Panel Lampholder, which has been developed specifically for the Armed Services. It is available with dimmer or indicator cap, and will withstand conditions of constant vibration and shock.

Brief details are given below, but further enquiries are invited.



DIMMER TYPE INDICATOR TYPE

THORN MINIATURE SEALED PANEL LAMP HOLDERS Overall length including contacts: 1.43 ins. Dia.: .75". Weights: with Indicator Cap 0.276 ozs., with Dimmer Cap 0.644 ozs. Conform to Radio Components Specs. (Prov.) 201, Humidity Class. H.1. Temperature category 40/100 (−40°C. to + 100°C.). Pressure sealed to 20 lbs./square inch.

Completely weatherproof and will withstand conditions of constant vibration and shock. Rotation of the dimmer cap controls the light output from bright to dim by means of an internal metal shutter. Developed originally for A.F.V.'s, Thorn Miniature Sealed Lampholders have many other obvious applications.

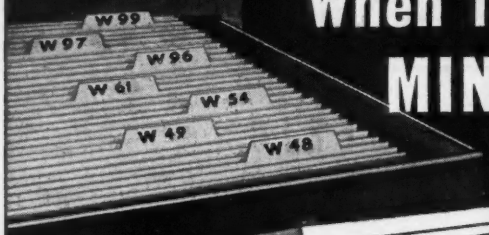
The holders are insulated from the panel which can vary from $\frac{1}{32}$" to $\frac{1}{8}$" thick. Thicker panels may be counterbored. Single hole mounting facilitates fitting. Rotation is prevented by flats on the body. The lamp can be replaced without breaking seals, by unscrewing cap.

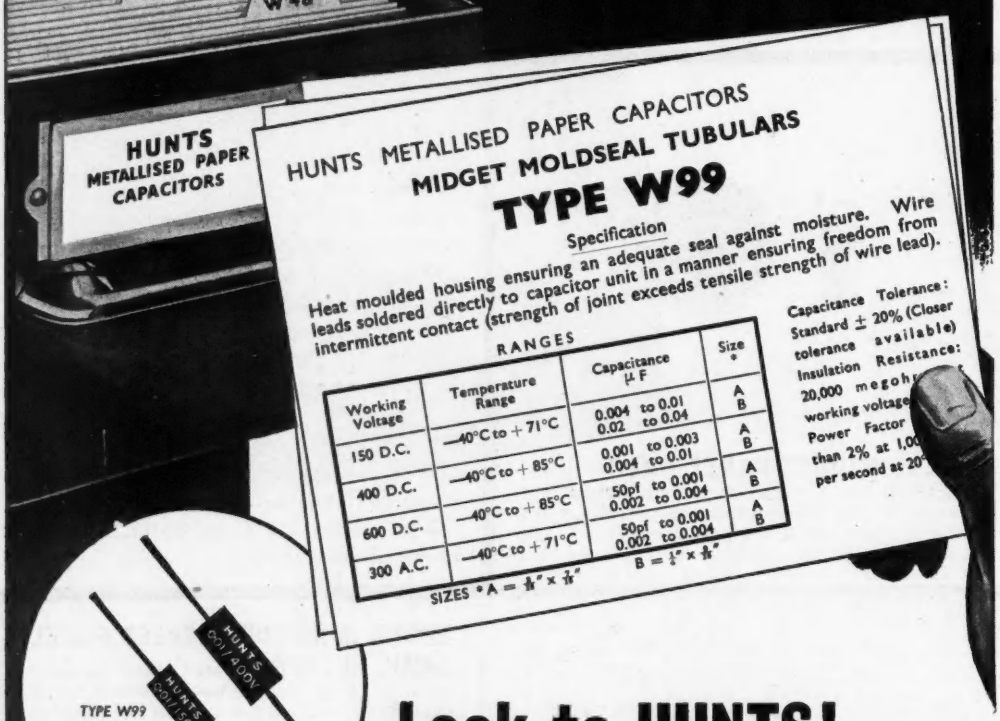
Thorn

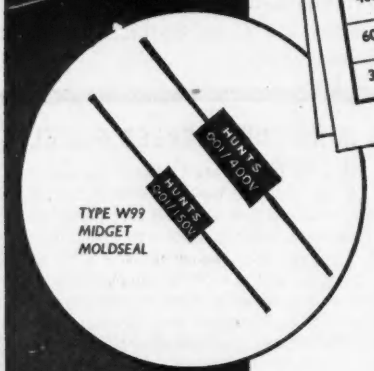
THORN ELECTRICAL INDUSTRIES LTD

AIRCRAFT COMPONENTS DIVISION, 105-109 JUDD STREET, LONDON, W.C.1

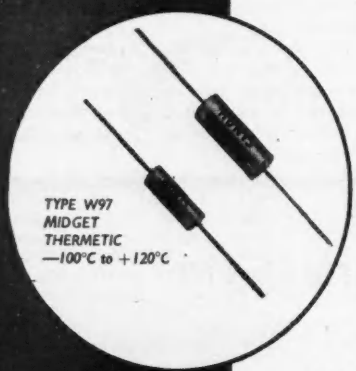
When it's a question of MINIMUM SIZES...







TYPE W99
MIDGET
MOLDSEAL



TYPE W97
MIDGET
THERMETIC
—100°C to +120°C

Look to HUNTS!

For maximum reliability. Hunts capacitors for radio and electronic equipment include many types designed to meet the need of designers for decreased dimensions.

Type W99 listed above is just one example taken from Hunts unparalleled range of capacitors for every purpose.

Years of specialisation in nothing but capacitor design and manufacture has enabled us to achieve and maintain that long-lasting reliability, and outstanding performance which characterises every Hunt product.

Please write for leaflet giving full details of types for all applications.

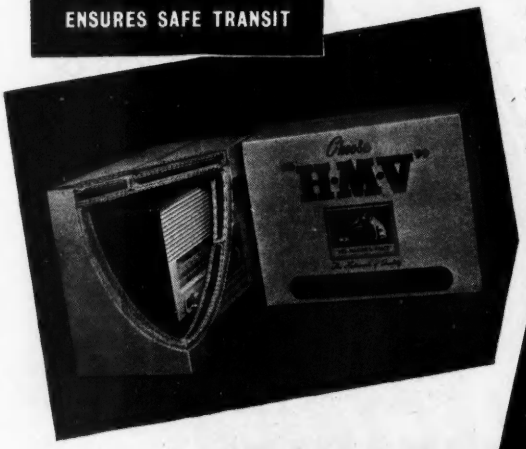
REGISTERED TRADE MARK
HUNTS
CAPACITORS
THE TRADE MARK OF RELIABILITY
Established 1901

A. H. HUNT (Capacitors) LTD., WANDSWORTH, LONDON, S.W.18 BATtersea 1083-7
and in Canada HUNT CAPACITORS (Canada) LIMITED, AJAX, ONTARIO

T&N *Precision-built*

CORRUGATED CONTAINERS

CUSHIONED PROTECTION
ENSURES SAFE TRANSIT



A PACK precision-built by Thompson & Norris is respected everywhere and saves money all round. Because of its cushioned protection and made-to-measure compactness, safe transit is assured, freight and storage costs reduced.

T & N are Britain's largest producers of corrugated fibreboard containers. Many world-famous products are clothed in packs of our design and manufacture. Our expert knowledge is at your service.

MADE TO MEASURE
PRINTED TO YOUR REQUIREMENTS

WE ARE EXHIBITING AT THE
Packaging Exhibition
By Provincial Exhibitions Ltd.
18-28 Jan. '55
National & Empire Halls
OLYMPIA
London

DIVISION OF Reed PAPER GROUP

THOMPSON & NORRIS

Pioneers of Corrugated Packaging

THE THOMPSON & NORRIS MFG. CO. LTD.

Head Office and Factory: Great West Road, Brentford, Middlesex.

Telephone: EALing 4555

Sales Offices and Factories are localised for maximum economic service:

CORSTORPHINE, EDINBURGH — *Telephone: EDINBURGH 67205*

SHIRLEY, BIRMINGHAM — *Telephone: SHIRLEY 1171*

WARRENPOINT, N. IRELAND *Telephone: WARRENPOINT 393*

Factory also at HISTON, CAMBS.

Let our Packaging Engineers give YOU the answer with scientifically produced cases, individually designed for YOUR products.

The experience and vast resources of Thompson & Norris as pioneers yesterday and leaders today of the Corrugated Fibreboard Industry, are available to YOU without obligation.

WATERPROOF OIL-PROOF

PRODUCTS OF RESEARCH TEST AND PRECISION MANUFACTURE

FLEXIBLE ELECTRICAL CONDUITS

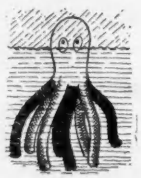
Supplied in four main types, summarised as follows :—

TYPE " NCC " Heavy duty type as supplied to the Services for cables subject to rough usage and exposure in severe outdoor conditions. Stands severe bending, and torsional movement. Supplied complete with required end fittings—attached specially to withstand pulling strains. Tough neoprene outer cover, or wire braided finish if desired.

TYPE " MC " Gives much greater flexibility than normal type of metallic industrial conduit. Outer covering of tinned copper braiding, affords full screening and electrical continuity between the end-fittings. Standard end-fittings and conduit threads.

TYPE " VMC " Generally similar to type " MC " but with an additional outer cover of PVC or Neoprene which gives added protection. Electrical continuity is maintained by the tinned copper braid immediately under the outer extrusion.

TYPE " VC " A light type of extreme flexibility, covered with a smooth PVC sleeving. Electrical continuity can be maintained by means of a tinned-copper bonding wire between inner and outer covers. Standard end fittings and conduit threads.



" Absolutely Waterproof, I assure you "
The Superflo:topus.

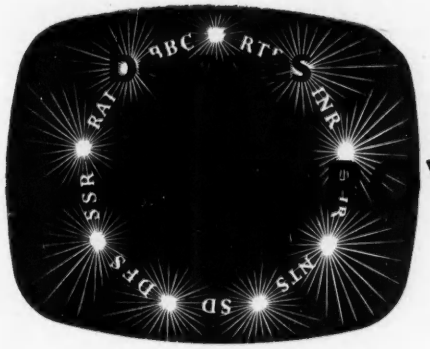
Enquiries to Dept. E.E.

SUPERFLEXIT LIMITED

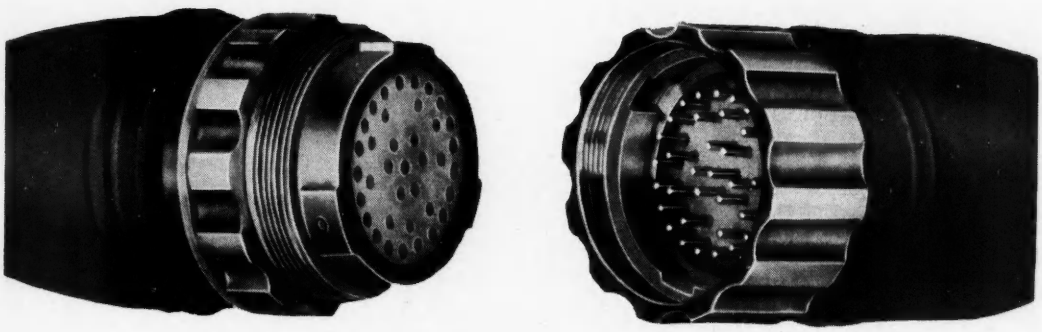
TRADING ESTATE · SLOUGH · BUCKS

Telephone : SLOUGH 24561 (5 lines)

TELEVISION



VISION



In the impressive link-up of national television services, large numbers of BICC Multi-Unit Cables and Polypole Couplers were used throughout Europe. They were employed with both V.H.F. link equipment and T/V cameras. These cables and couplers are designed to provide a robust trailing cable system to withstand the hazards of outside television service. For further information please ask for Publication T.D. T. 15.

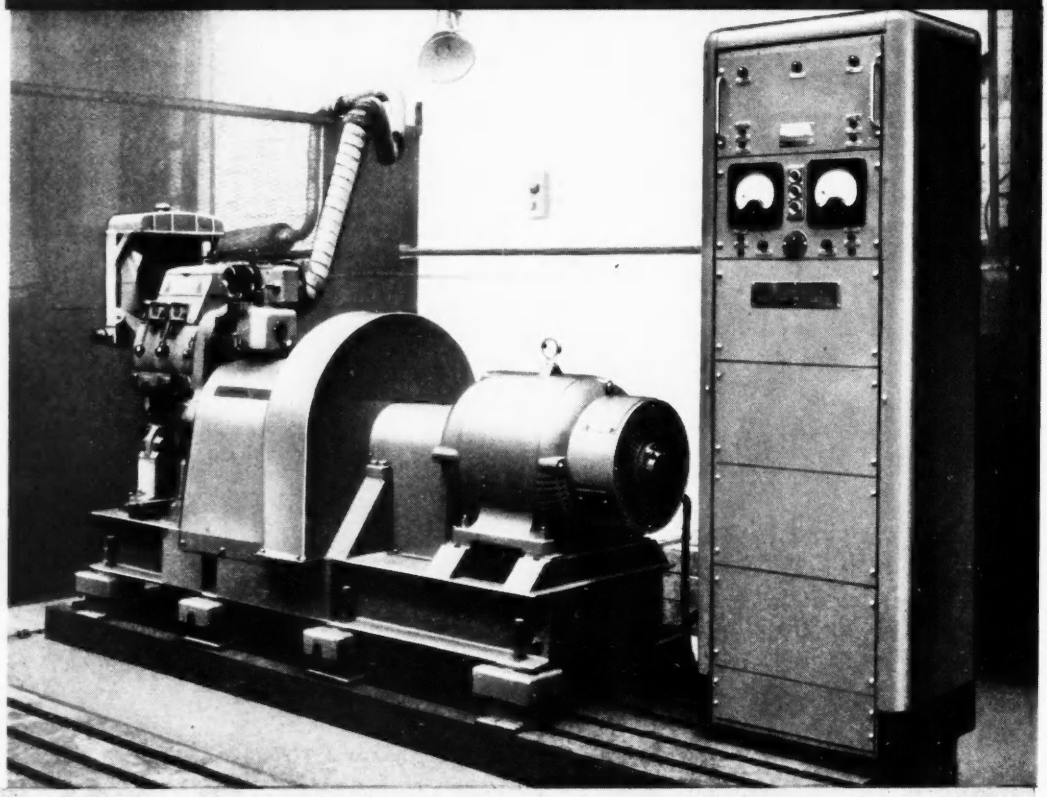
BICC multi-unit cables and polypole couplers

BRITISH INSULATED CALLENDER'S CABLES LIMITED
21 BLOOMSBURY STREET, LONDON, W.C.1

BI Callender's

NO-BREAK ENGINE-ALTERNATORS

E.C.C. PATENTS



"NO-BREAK" SET WITH CONTROL CUBICLE.

These NO-BREAK Alternator Sets are arranged to operate in conjunction with existing A.C. mains to provide a continuous A.C. supply for essential services such as telecommunications, etc. Normally the vital service is fed from the supply mains and, under conditions of mains failure, from the diesel driven alternator set.

Under normal conditions the A.C. mains supply power direct to the load, the alternator operating as a synchronous motor driving a fly-wheel, with the diesel-engine stationary. Under mains failure conditions the alternator is driven by the diesel-engine to supply power to the load. On restoration of the ordinary supply mains the alternator synchronises automatically with these mains, the diesel-engine is again disconnected and the alternator operates as a synchronous motor.

Each set incorporates a Lister FREEDOM diesel engine and an E.C.C. synchronous induction motor/alternator. E.C.C. patent static excitation and control unit is incorporated in the control pillar.

E.C.C. patent ECCOSYNE automatic synchronising unit is provided for re-connecting the alternator to the mains on mains restoration. These sets ensure a continuous NO-BREAK supply both in attended and unattended stations.

Brochure B.1739—available on request.

ESTABLISHED 1882

THE ELECTRIC CONSTRUCTION COMPANY LTD.

TELEGRAMS: ELECTRIC WOLVERHAMPTON

Head Office and Works: BUSHBURY ENGINEERING WORKS WOLVERHAMPTON ENGLAND

TELEPHONE: WOLVERHAMPTON 21455 (7 LINES)

2746

Manufacturers of Rotating Electrical Machinery, Switch and Control Gear, Rectifiers and Transformers.

Precision Cathode Ray Tubes

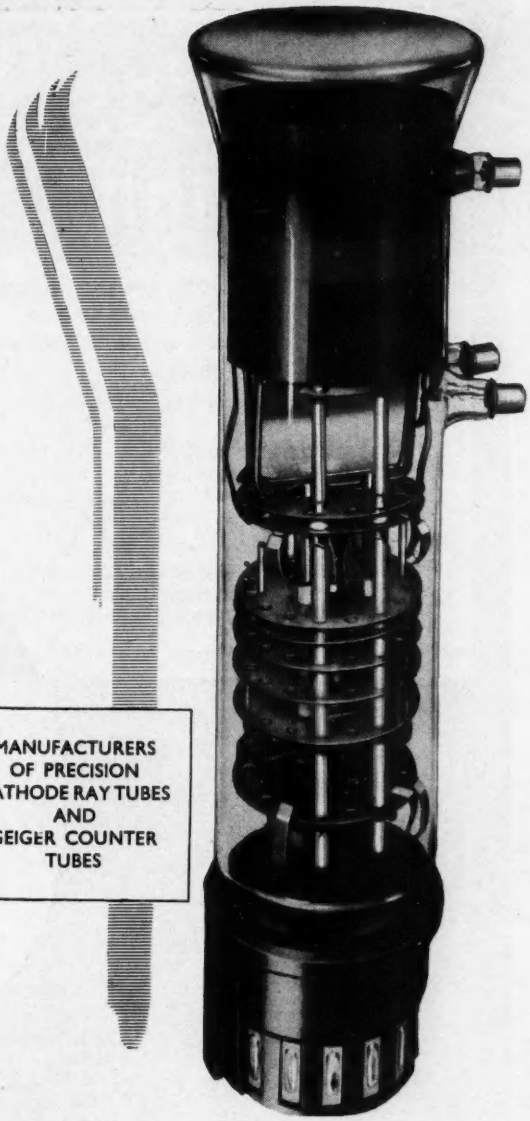
High Speed Recording Tube
Single Beam
Series S3A

This is a 3½" tube employing a single stage of post deflection acceleration and having a flat face ground and polished both internally and externally. The X deflector plates are brought out to side-arms.
An accurately aligned gun gives freedom from spot aberrations and a minimum of trapezium distortion. Supplied with a blue screen and operated with a total accelerating potential of 8 KV, the tube is capable of recording a 100 Mc/s sine wave, 2 cms. peak to peak, with a sweep speed of 90 cms. per microsecond.

Type		S3A
Diameter		90 mm.
Overall length		335 mm.
Sensitivity ... ... mm./V { VA_3=4 KV ...	X	0.10
{ VA_4=8 KV ...	Y	0.12
Plate Capacity	X	6 μμF
	Y	5 μμF
Heater Volts		4.0*
Heater Amps		1.5
VA_4 max. KV		8
VA_3 max. KV		4
VA_1 max. KV		2
VA_2 (VA_3=4 KV) Volts		200

* 6.3 V *heater available on special request.*

Screens:
S3AB — Blue for photographic or visual use.
S3AG — Green for visual observations.
S3AP — Medium persistence.
S3AF — Fluoride. Long persistence.
S3AD — Double screen. Long persistence.



MANUFACTURERS OF PRECISION CATHODE RAY TUBES AND GEIGER COUNTER TUBES

20th Century Electronics Limited

20th CENTURY ELECTRONICS LTD.
Telephone: Springpark 1026

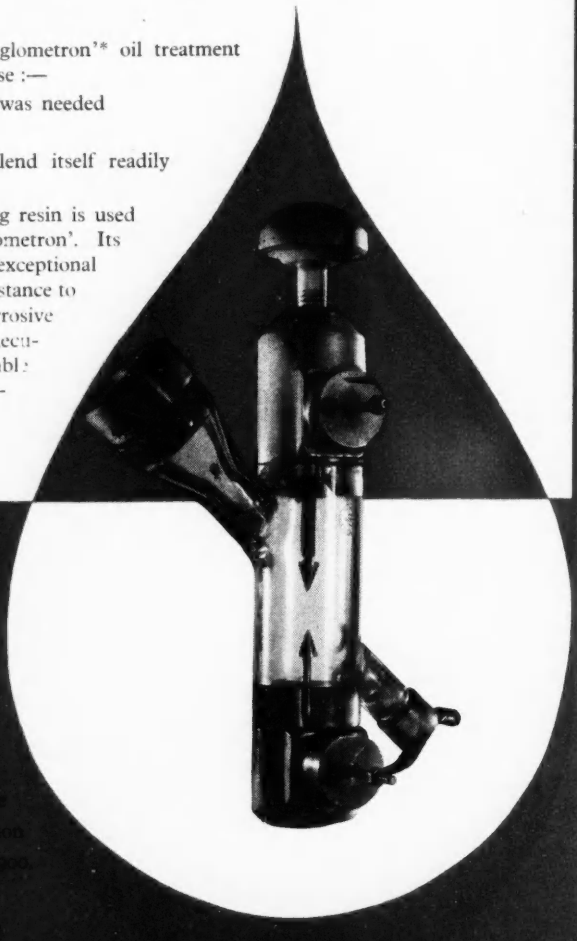
CENTRONICS WORKS · KING HENRY'S DRIVE
NEW ADDINGTON · SURREY

Cast in ARALDITE

This component is a part of the 'Agglometron'* oil treatment chamber. It was cast in 'Araldite' because :—

* An outstanding electrical insulator was needed
* It had also to be oil-resistant
* It was important that it should lend itself readily to casting and machining.

'Araldite' as a casting and as a bonding resin is used in many components of the 'Agglometron'. Its electrical and mechanical properties, its exceptional adhesion to metals and ceramics, its resistance to high temperatures, humidity and corrosive agents suggest other uses in which the execution of new designs can be made practicable and the production of electrical components greatly simplified. May we send you full descriptive literature ?



* An electrical device developed by Mr. O. E. Nebella of Messrs. Metrovic Ltd. (a subsidiary company of J. & E. Armfield Ltd.) for agglomerating impurity particles in circulating oil to facilitate filtering. The name 'Agglometron' is a registered trade mark for the high voltage treatment chamber included in the filtration plant and is covered by B.P. 698,000.

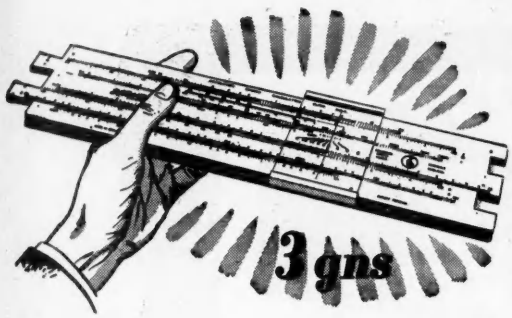
THESE ARE THE NEW EPOXIES!

'Araldite' (regd.) epoxy resins are obtainable in the following forms :—

- Hot and cold setting adhesives for metals and most other materials in common use.
- Casting Resins for the electrical, mechanical and chemical engineering industries.
- Surface Coating Resins for the paint industry and for the protection of metal surfaces.

'Araldite' EPOXY CASTING RESINS

Aero Research Limited, DUXFORD, CAMBRIDGE. Telephone: Sawston 185. A Ciba Company



Cut the stress and strain from spring calculation

WITH A 'RATCLIFFE' SPRING CALCULATING SLIDE RULE

★ Scales allow all calculations involved in the design of helical tension and compression springs to be made *at one setting!*

★ Upper slide for stress and load calculations!

★ Wahl's stress correction calculated quickly!

★ The rule is essential to engineers and draughtsmen, is soundly constructed and supplied in a strong case complete with instructions.

★ Price £3. 3. 0.. Send for one today.

J.S. Ratcliffe
THE SPRING SPECIALIST

CRAWFORD SPRING WORKS
ALLEN STREET • ROCHDALE • LANCS

Electronic Engineering

Incorporating ELECTRONICS, TELEVISION and SHORT WAVE WORLD.
Managing Editor H. G. Foster M.Sc. M.I.E.E

Vol. 27 JANUARY 1955 No. 323

Contents

Commentary	1
An Audio-Frequency Meter — By P. G. M. Dawe and J. A. Deutsch	2
A Novel Gas-Gap Speech Switching Valve — By A. H. Beck, T. M. Jackson and J. Lytollis	7
A Low-Frequency Pulse-Train Generator — By J. E. Flood and J. B. Warman	13
Stabilized D.C. Supplies Using Grid-controlled Rectifiers — By L. Knight	16
C-Band Weather Radar	20
A Versatile Output Transformer for Surge Generators — By J. D. Harmer and J. R. Howells	22
Wide-Range Operation of Grid-controlled Rectifiers — By D. H. McEwan	24
New Marconi Training College	27
The London-Sydney Cable Circuit — By A. H. Harris	28
Class-C Amplifier and Oscillator Design — By L. T. Apps	30
An Electronic Nyquist Diagram Plotter — By J. L. Douce	32
An Alternating-Voltage Stabilizer — By D. J. R. Martin	35
Electronic Machine Tool Control	37
New Australian Army Midget Radio	37
Notes from North America	38
Letters to the Editor	39
Electronic Equipment	40
Book Reviews	42
Short News Items	45
Meetings This Month	46
Publications Received	46

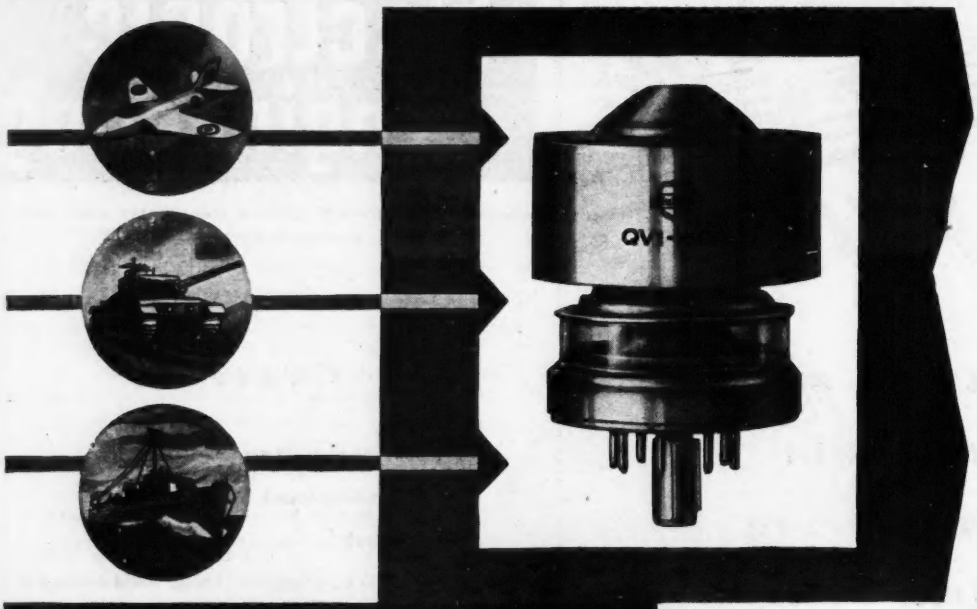
Published Monthly on the last Friday of the preceding month at 28 Essex Street, Strand, London, W.C.2.

Telephone: CENTRAL 6565
Telegrams: 'LECTRONING, ESTRAND, LONDON'

Subscription Rate:
(Home or Abroad) Post Paid 12 months 26s. or $4 (U.S. or Canada)

Classified Advertisements, Page 1
Index to ADVERTISERS, 121 and 122

FOR AIR, LAND AND SEA U.H.F. STATIONS



QV1-150A POWER TETRODE

The new Mullard QV1-150A is an external anode tetrode of exceptionally small dimensions, completely interchangeable with the popular American 4X-150A. It is forced-air cooled and will operate with excellent efficiency and power gain at frequencies as high as 500 Mc/s.

Although the maximum d.c. anode voltage is 1.25kV, the performance of the QV1-150A is little reduced at half this figure and recommends it for both fixed and high power mobile transmitting equipments.

High permissible anode dissipation, high current density and very favourable ratio of mutual conductance to capacitance particularly suit this new tetrode for wide-band applications.

The modified loctal base of the QV1-150A is so arranged that, when equipped with its special socket, forced-air cooling is facilitated and coaxial or linear circuits may be used. Excellent circuit separation is achieved at U.H.F. by a disc-seal screen-grid connection located between anode and base which is by-passed to cathode by a capacitor built into the socket.

Further information on this and a wide range of other transmitting valves may be readily obtained from the address below.

Typical Applications	Va (kV)	Pload (W)	f(Mc/s)
R.F. POWER AMPLIFIER			
Class "B" (Television Service)	1.25	200	216
Class "C" Telegraphy and F.M. Telephony	1.25 1.25	156 112	165 500
Class "C" Anode Modulated	1.0	112	165
A.F. POWER AMPLIFIER AND MODULATOR (two valves)			
Class "AB1"	1.25	310	A.F.
Class "AB2"	1.25	425	A.F.

HEATER		LIMITING VALUES			BASE
Vh	6.0V	Va max.	1.25	kV	B8F
Ih	2.6A	pa max.	150	W	
		Vg2 max.	400	V	
		pg2 max.	12	W	
		f max.	500	Mc/s	

Mullard

MULLARD LTD., COMMUNICATIONS & INDUSTRIAL VALVE DEPT. CENTURY HOUSE, SHAFTESBURY AVENUE, W.C.2.

MVT 168

ELECTRONIC ENGINEERING

VOL. 27 No. 323

JANUARY 1955

Commentary

INTEREST in the fully automatic process controlled factory has been considerably aroused by the address given last November by Sir Ben Lockspeiser, Secretary of the Department of Scientific and Industrial Research to the Working Conference on Research and Productivity. It is all the more unfortunate therefore that in the space devoted in the Press to this intriguing subject so much of what he said was misinterpreted.

In the lay mind there is the impression that the automatic factory is a completely new idea made suddenly possible by electronics and that very shortly such factories will spring into being in which raw materials will be fed in at one end and from the other will pour forth in abundance finished products such as motor cars, refrigerators, television sets and the like. By some magical assembly of servo mechanisms and electronic "brains" the whole process will be carried out continuously without human intervention and all we have to do to initiate this process is to press a button.

Nothing is further from that envisaged by Sir Ben Lockspeiser and it may be well worthwhile to probe a little deeper into what is meant by automatic process control and the automatic factories.

Automatic process control is no more than the logical development of the automatic devices which have surrounded us for centuries and the only new thing is the name we now give it. The classical automatic control device is, of course, the governor on the original steam engine of James Watt and it was brought into being to replace the boy—the human operator in twentieth century parlance—on the steam valve and so provide an automatic means of keeping the engine speed constant irrespective of load fluctuations.

But such error-actuated devices to replace the human operator go further back than the governor on the steam engine. It can be claimed with justification that the temperature-compensated pendulum invented by Harrison in 1726 is such a device, and going back still further into the past so is the turret clock of Salisbury Cathedral which struck a bell to mark the passage of the hours.

This was made in 1386 and as a point of interest it still survives.

As man improved his tools and processes or invented new ones it was only natural that he should fit his various automatic devices to relieve him of the tedium of frequent correction. When he made his first windmill he arranged matters so that it could of its own accord always face the direction of the wind and what he had done in fact was to construct an "automatic factory" which would mill his corn for him as long as the wind blew.

Since the industrial revolution of some hundred and fifty years ago we have made enormous strides both in the intricacy of our machines and in the ingenuity with which we control them, and automatic control of the machine is a feature of our age.

During the last war the need for munitions of all kinds in enormous quantities forced us to review many of our manufacturing methods. Jobs had to be broken down and operations simplified so that what had previously demanded judgment and experience could be performed by unskilled labour working automatic controlled machines.

These techniques were incorporated in the post war development and were further improved and adapted to meet the demands made by such new products as jet engines where an extremely high degree of accuracy is required.

The simple capstan lathe turning out its small finished parts is an automatic factory in itself and so at the other end of the scale are the continuously operated processes common to oil refining. Many of the manufacturing processes in chemical engineering are almost entirely "workerless" in that they are self-operated and electronically controlled, with minimum overriding human command.

What then is this new vision of the "push button" factory? Our capstan lathe has to be set up initially and adjustments have to be made by trial and error until its product conforms to standard. Once set up, it will continue to operate, but it cannot inspect its own workmanship nor can it correct for deviations. Neither can it count and batch.

It would not be economical to control the capstan lathe by electronic methods, but in the more complicated operations and processes where stage by stage control is essential electronics has already taken over many of the existing hydraulic, pneumatic and mechanical methods with remarkable results. To this extent the automatic factory is already in being.

What has taken us by giant strides towards our new conception of the automatic factory is the electronic computor and we are now in fact contemplating the marriage of the computor to the machine tool. To this union the title of "automation" has been given.

The computor with its facilities for memory storage lends itself admirably to advance programming and it now appears practicable to make it control a machine tool performing intricate machining operations.

The combination of these two will undoubtedly form the basis of the automatic factory of the future. We have a long way to go before every industrial process is a push button operation, but we can expect to see some notable advances before many years have elapsed.

AN AUDIO-FREQUENCY METER

for Graphing Frequency Variations in the Human Voice

By P. G. M. Dawe*, M.A., M.Sc., and J. A. Deutsch*, M.A.

An instrument is described which produces a d.c. output voltage directly proportional to the frequency of an input voltage. It is used to operate a pen recorder, and it will follow variations in input frequency with a lag of approximately one cycle on the input waveform, since no integrating networks are used. The instrument is being used to aid psychological investigations into the mechanism of voice production.

IN certain psychological experiments into the mechanisms controlling the production of a singing tone by the human voice it is necessary to have some means of recording small frequency variations produced when a subject is asked to sing a given note, or to move from one note to another under various imposed conditions. The audio-frequency meter here described is an instrument designed for this purpose, to give a d.c. or slowly varying output voltage which will be practically instantaneously proportional to the frequency of the input voltage. This output is used to operate a pen recorder. The frequency ranges which the instrument is designed to cover are from 90 to 180c/s and from 180 to 360c/s, these being the ranges of most interest in examining the behaviour of the human voice.

It is useful to have the frequency converted into a continuous d.c. output because it is possible to use a pen recorder with comparative economy. The instrument extends greatly the range of usefulness of any pen recorder when frequency measurement is needed, for the frequency response of the pen recorder needs only to be as good as the fluctuations of the frequency and not as the frequency itself.

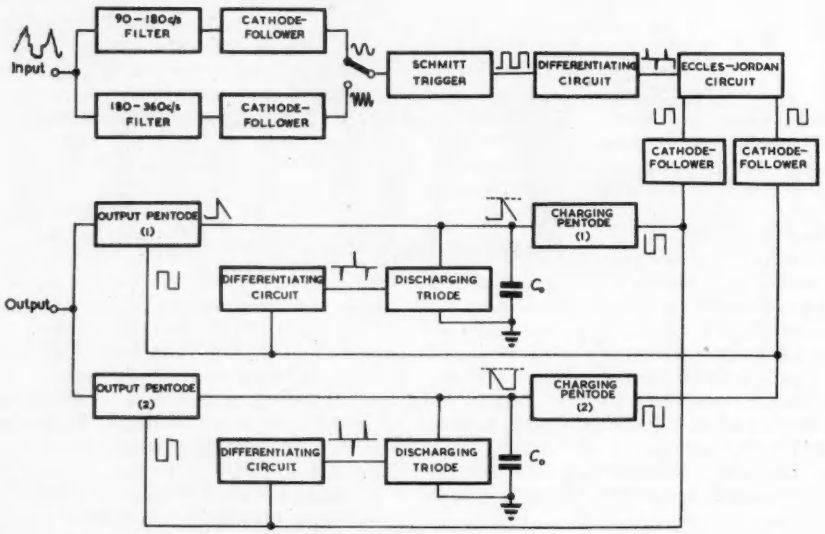


Fig. 1. The audio-frequency meter

Second, the frequency meter has conveniently been employed not only as a recording instrument alone but also as an integral part of the other experimental apparatus. The d.c. derived has been used to control the frequency output of an oscillator, the sound of which has been fed back greatly amplified to the subject. It has been possible, for example, to invert the perceived direction of error of the voice, or to exaggerate the frequency change in the same direction.

Finally, it is considered that this type of frequency metering may be useful in studies of speech recognition, where a number of meters could be used in parallel to cover various frequency ranges. The sensitivity of this type of frequency meter approximates closely to that of the human ear both in its capacity to "recognize" small frequency differences and its resolving power in time,

*Institute of Experimental Psychology, University of Oxford.

since no integrating device is incorporated in its design.

Circuit Arrangement of the Instrument

A block schematic of the instrument is shown in Fig. 1, together with the waveforms at the various points of the circuit. It is seen that the basic principle on which the instrument operates is by recording, for each cycle in turn, the charge or voltage acquired by a capacitor, this being made proportional to the frequency of the input wave. A square wave is first produced from the input frequency the period of which is used to determine the voltage reached by two capacitors C_0. Each capacitor is charged through a pentode on alternate half-cycles of the square wave by using this wave as a switching waveform applied to the control grids of the pentodes. The d.c. voltage acquired by the capacitors is then a measure of the frequency of the input wave.

The principle of operation for the meter is similar to that used recently, for example, in an instrument designed to detect small frequency shifts in a 10kc/s source[1], and in a pulse interval meter for physiological use[2]. However, the basic principle was developed independently in prototype form by J. A. Deutsch, working in London at the Department of Phonetics in 1950, and the particular application of it in this instrument may be of some general interest.

The Filter Circuits

The input wave is fed directly to the paralleled input of two filters which separate the two octaves, 90 to 180c/s and 180 to 360c/s. Each filter consists of two *RC* type valve resonant circuits joined in cascade, each circuit using a double triode valve and a two-mesh *RC* network. The two filters are identical except for the values of *R* and *C*. The circuit for these filters is shown in Fig. 2, together with their subsequent cathode-follower stages. For each resonant circuit the two triodes are connected in series across the h.t. supply, the input signal being injected into the grid of the upper triode, while the control grid of the lower triode is fed with the phase shifted voltage from the output of the *RC* network.

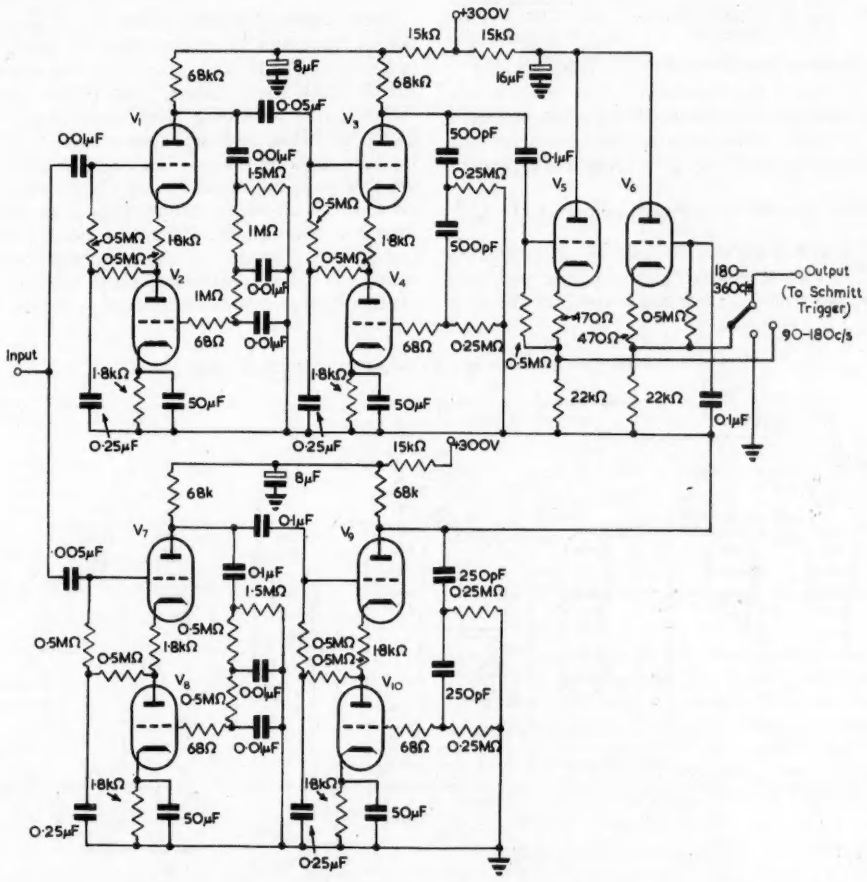


Fig. 2. Filter circuits for the octaves 90 to 180c/s and 180 to 360c/s

The principles of design of this type of resonant circuit was first discussed in the literature by Dr. E. E. Schneider[3] and it may be noted that such circuits have an inherently low Q value, since this is proportional to the square root of the effective stage gain across the *RC* network. In the case of the two valve circuits used in Fig. 2, the effective overall gain, *m*, developed across the *RC* network, between the grid

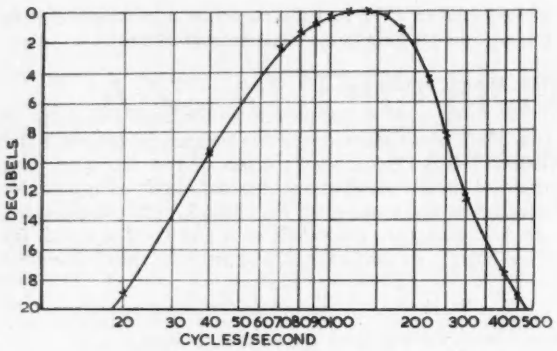


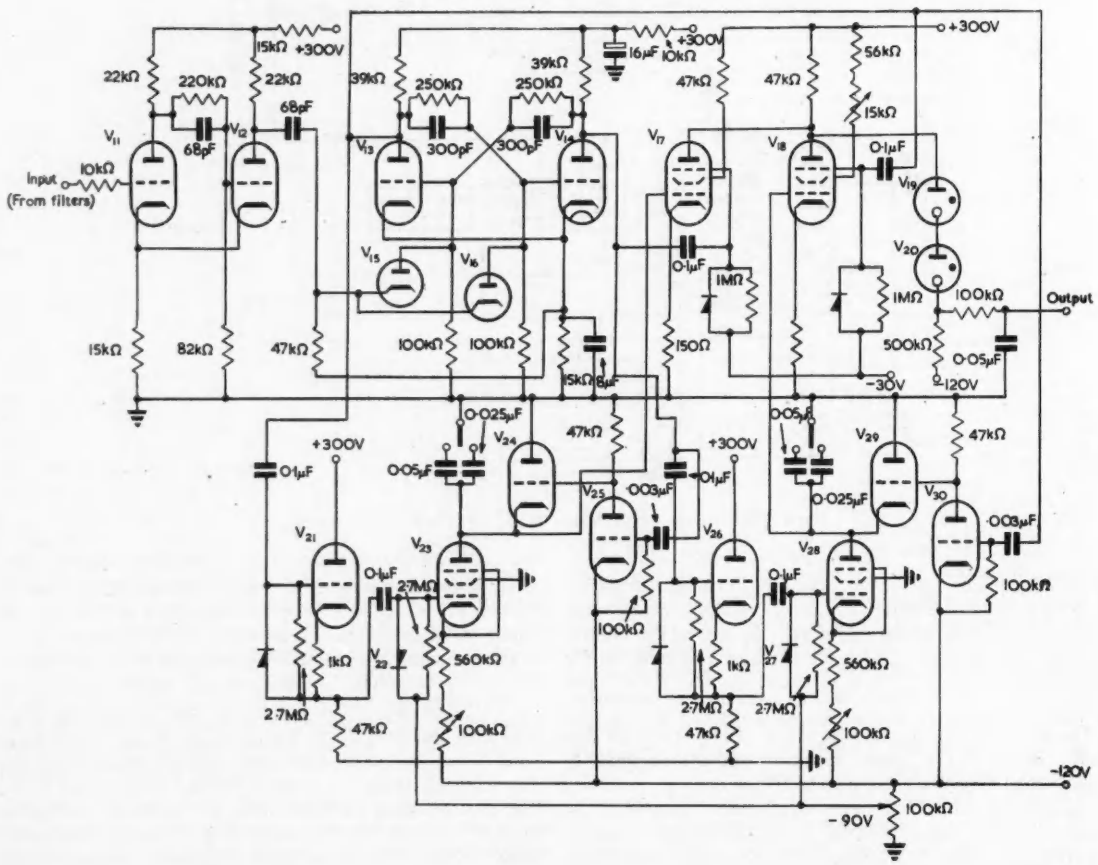
Fig. 3. Response characteristic for the 90-180c/s filter

of the lower triode and the anode of the upper triode, is approximately 55 times. Where m is considerably larger than unity, and the capacitors have negligible losses, the expression for the Q of these resonant circuits may be reduced to $\sqrt{\frac{m}{3}}$. This gives Q values for the circuits used of approximately 2·5. Such low Q values, however, are not any particular disadvantage in this instance since the purpose of the filter is to discriminate against the harmonics in the input wave. It is found that for a frequency at the lower edge of the pass-band, i.e. 90c/s, an attenuation of greater than 10dB may be obtained for the third harmonic, greater than 15dB for the 4th, and 20dB for the 5th, respectively. For higher frequencies, within the pass-band, the suppression of harmonics is correspondingly better, but even at 90c/s this type of filter proves satisfactory when used with quite complex input waves. Fig. 3 shows a characteristic of the 90 to 180c/s filter, the two resonant circuits being tuned to 110c/s and 170c/s.

The Square Wave Generators

The square waves controlling the charging period of the output capacitors are derived from the filtered input wave in two stages. The filtered wave is first fed to a Schmitt trigger circuit which gives a square wave of the same frequency as the triggering waveform. This square wave is differentiated by the following short time-constant *RC* network, to produce further triggering pulses. The negative going pulses are fed via diodes to an Eccles-Jordan circuit, each negative pulse causing this circuit to switch over. Two square waves are therefore obtained from the two Eccles-Jordan valves, of one-half the frequency of the input waveform to the instrument, and 180 degrees out of phase with each other. These are therefore used as the switching waveforms in the following

Fig. 4. Square wave generators and the output stages for the frequency meter



output circuits. This method of obtaining the switching waveforms avoids any small variations in mark-space ratio which may otherwise occur by variations in the backlash (i.e. switching potentials) of the Schmitt trigger, and ensures that the two output capacitors are charged for equal intervals of time, each corresponding to one complete period of the input waveform. Fig. 4 shows this part of the circuit together with the following output stages.

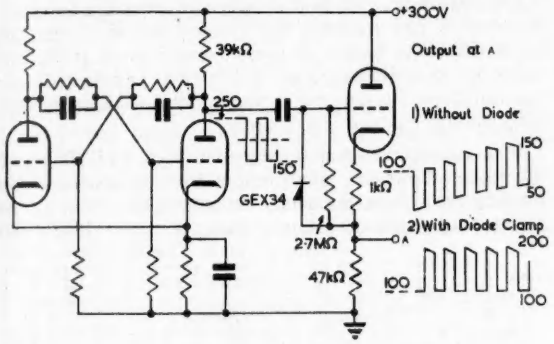


Fig. 5. The use of a restoring diode to maintain a short time-constant at the output of the square wave generator

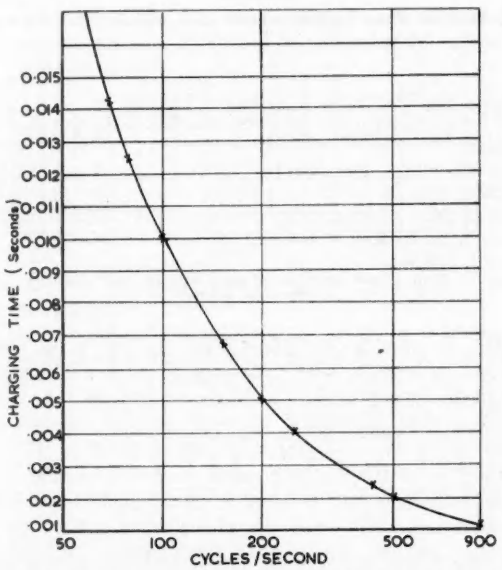


Fig. 6. Graph relating capacitor charging time with the logarithm of the input frequency

The switching waveforms are fed to the output circuits via two cathode-follower buffer stages, one following each of the Eccles-Jordan valves. The coupling networks both to these cathode-follower valves and from them to the output stages are provided with diode clamps to allow the coupling capacitors to discharge or charge rapidly to a new steady value on the application of an input waveform. For the circuit shown in Fig. 5, where the right-hand anode of the Eccles-Jordan pair is cut off and at 250V above earth, there will be a steady change of average voltage at this anode of 50V when the input wave comes on, since a 100V square wave will now be produced at this anode. The coupling capacitor would therefore tend to discharge slowly by 50V through the grid leak in order to maintain the same effective d.c. level at the cathode of V_2. The clamping diode, however, will cause the capacitor to discharge rapidly by the full value of the 100V anode swing, so that the output from the cathode will be a 100V square wave added to the previous d.c. level at the cathode. Without the diode, the slow variation in charge on the coupling capacitor can make the output circuit sluggish in coming into operation, since the output level from the cathode-follower may at first be too negative to enable the square wave to be effective in switching the charging valves on and off.

The Output Stage

This consists, as previously stated, of two capacitors which are charged during alternate half-periods of the switching waveform (one period of the input waveform) to a voltage

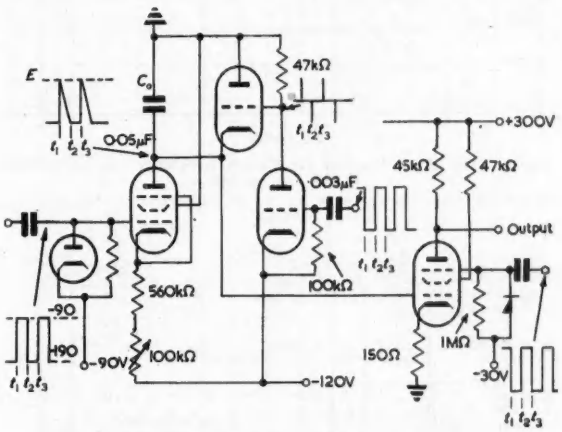


Fig. 7. Operation in detail of one side of the output stages

proportional to the period of this wave, and whose voltage during the ensuing half-cycle is held constant and used to determine the grid potentials and therefore the anode potentials of two output valves. These are operated in parallel so that the d.c. output voltage is determined over the whole cycle of the switching waveform. They are switched so that one is supplying the output potential while the grid capacitor of the other is being charged.

A further coupling capacitor and clamping diode is used to couple the square wave output from the cathode-follower, $V_{21,26}$ to the pentodes, $V_{22,28}$, charging the output capacitors (see Fig. 4). In this case the diode clamp holds the d.c. level of the pentode control grid at the bias voltage of the grid leak return, − 90V, and the 100V square wave subtracts on this level, so switching the pentode (see Fig. 7).

The capacitors are charged negatively from earth through pentodes having a high value of cathode load to give an approximately linear charging characteristic.

It should be realized that if the pen recorder is to have a logarithmic frequency scale, the charging characteristic for the capacitors will need to be of a special form. If the capacitors are charged linearly for a time given by the reciprocal of the input frequency, the relationship between charging time, or voltage, and the logarithm of the frequency is as shown in Fig. 6. Since this is a curve, the frequency

compression at the top end of the scale would be unduly large. Ideally, a straight line is required, for then the characteristic of the instrument would correspond closely to to the logarithmic discrimination of the ear. However, it is found in practice, that the small curvature of this relationship over the range of interest can be fairly well compensated for by the curvature of the mutual characteristic of the following output valve, whose grid voltage is taken from across the capacitor. It was not considered necessary therefore to complicate the circuit at this point in order to get an exact logarithmic relationship, especially since calibration can be very easily performed, and the frequency ranges being used at any given time were small, usually about 30c/s in width. The capacitors therefore provide a voltage of the correct magnitude and sign for connecting directly to the grids of the output valves, which are operated without grid leaks in

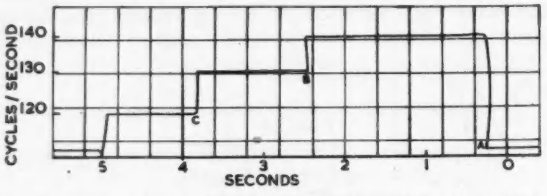


Fig. 8. Copy of pen recording for 3 steady frequencies from an oscillator of 120, 130 and 140c/s

(Recording paper stopped at B, C and D while oscillator frequency was changed.)

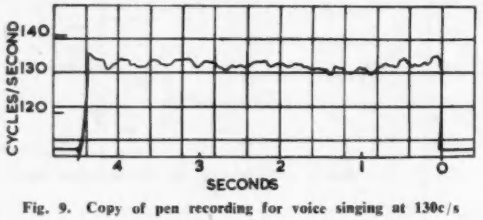


Fig. 9. Copy of pen recording for voice singing at 130c/s

order to avoid any slow discharge of these capacitors. They are discharged only at the end of a complete cycle of the switching waveform, their voltage being held constant during the latter half of the cycle, since the pentode is then non-conducting. The discharging is done by differentiating the appropriate switching waveform and using the amplified trigger pulse simply to discharge the capacitor through a triode switched on by the pulse. The duration of this discharge is not particularly critical, provided that it is short compared with the charging time, and if small capacitors and correspondingly small charging currents are used, a discharge almost to earth potential can be obtained quite satisfactorily. Fig. 7 gives a separate diagram of this part of the circuit with the waveforms at the various points to make the operation clear.

It is obviously of some importance that the paralleled output valves be well matched if a high sensitivity is required without the appearance of any ripple voltage at the output. Some selection of valves may therefore be necessary at this point, but this is minimized by the addition of some negative feedback in the form of a cathode resistor to make the grid base less dependent on the valve characteristics, and also by providing for a variable adjustment of the screen voltage on one of the output valves. Any residual a.c. ripple may be removed by the addition of a small capacitor across the output of the stage, provided that the time-constant introduced by it is not excessive. The valve used in this application was the 6F33 short suppressor grid base pentode. It is seen that two small neons are used to back off the h.t. voltage from the output, and the residual ripple is removed by the use of a 100kΩ series resistor and a 0·05μF shunt capacitor.

Sensitivity and Results

The instrument was used in conjunction with a Southern Instruments pen recorder Type M.944 and d.c. amplifier Type MR.341 B, to give an overall sensitivity of 1cycle/mm deflexion. Sensitivities greater than this may be obtained from the instrument but were not required in this application. The input voltage required is 10V r.m.s.

Four records obtained are shown in Figs. 8-11. In Fig. 8 the record shows the 140c/s output from an oscillator and loudspeaker system, the sound being switched on at A. At B and C the oscillator output is changed to give 130c/s and

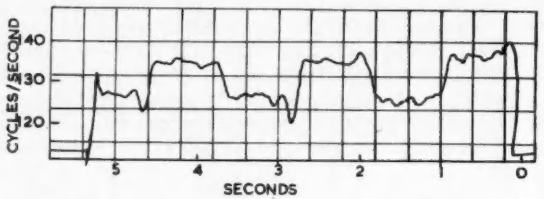


Fig. 10. Copy of pen recording for voice singing between 125c/s and 135c/s

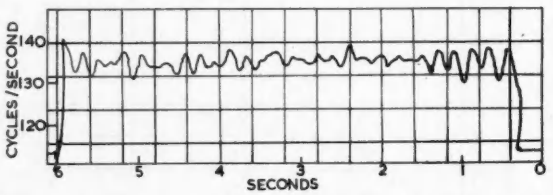


Fig. 11. Copy of pen recording of more resonant voice singing a 125c/s note from memory

120c/s to provide calibration levels. In Fig. 9 the record shows the human voice attempting to pitch a 130c/s note from memory, while in Fig. 10 the response of the voice is shown when attempting to move steadily between two frequencies of 125c/s and 135c/s, as remembered from the two sounds given previously. Fig. 11 shows a more trained singing voice producing a 135c/s note.

Acknowledgments

The authors wish to gratefully acknowledge the encouragement and financial help given to them by the Medical Research Council which made this work possible, and the facilities afforded by the Department of Phonetics, University College, London, and the Institute of Experimental Psychology, Oxford.

Dawe Instruments Ltd., of Ealing, are planning to produce a commercial version of this frequency meter which may be of interest to a wide variety of users.

REFERENCES

1. Barker, R. G., Connor, G. L. The Periodmeter. *Wireless Engr. 30*, 274 (1953).
2. Andrew, A. M., Roberts, T. D. M. A Pulse-interval Meter for Measuring Pulse Repetition Frequency. *Electronic Engng. 26*, 469 & 543 (1954).
3. Schneider, E. E. A New Type of Electrical Resonance. *Phil. Mag. 36*, 371 (1945).

A Novel Gas-Gap Speech Switching Valve

By A. H. Beck*, B.Sc., A.M.I.E.E., T. M. Jackson* and J. Lytollis*, M.A.

A new gas discharge circuit element is described. It has the following properties; low resistance (circa 100Ω) when struck, the resistance being constant for all frequencies up to at least 50kc/s, the reactive component of the impedance is negligible and the noise voltages are at least 60dB below signal levels. The development of such devices considerably simplifies major problems in electronic telephone exchange design.

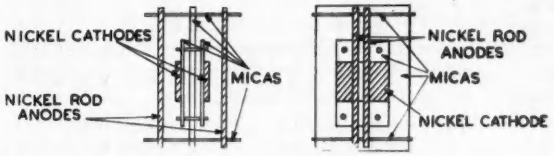
THE all-electronic telephone exchange has been the subject of much research in the last decade. One of the simpler ways of making such an exchange seems to be the direct replacement of the crossbar switch by electronic devices, each junction of the mechanical switch being replaced by a suitable electronic device. The more obvious requirements of such a device are:

1. That it can be switched rapidly from a high (practically infinite) a.c. impedance to a low (practically zero) a.c. impedance.
2. That it shall transmit voice frequencies at milliwatt power levels without either frequency or amplitude distortion.
3. That it shall not introduce electrical noise.
4. The device should form part of the line circuit and the switching operation should be performed by pulses in the line circuit.

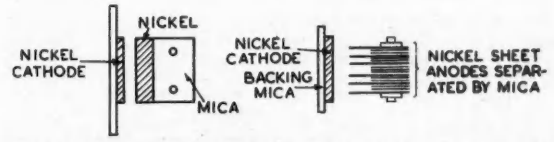
A cold-cathode gas-filled valve is an obvious device to investigate for the purpose outlined because the glow discharge can be initiated and extinguished directly by pulses, and there is a definite break between the conducting and non-conducting state within a time of the order of 1 millisecond. There are other advantages in using a cold-cathode gas-filled valve. When in a non-conducting state the valve consumes no power; rapid fault diagnosis is possible because the glow is easily visible; and such valves have long lives.

The main difficulty to be overcome is that of providing a sufficiently low resistance path for reasonable direct currents in the conducting state. Bell Telephone Laboratories[1] have produced a diode gas-gap using a hollow cathode discharge which gives a small power gain in the frequency range of 50 to 3 000c/s and operates with direct currents in the range 10 to 20mA. It is not known whether this valve can be switched and used directly in the line. This article describes an electrode arrangement for gas-filled valves which gives a noise free, low resistance path for d.c. and a.c. signals, the upper frequency for the a.c. signals being at least 50kc/s. This device satisfies the other requirements stated in this introduction. Several different electrode structures are possible and two practical valves using the arrangement are described.

The electrode arrangement consists essentially of a cathode with two electrodes acting as joint anodes equally spaced from the cathode surface. These anodes can be of any geometrical shape provided a normal projection from them in the direction of the cathode will meet the cathode surface. There is a limit to the anode-cathode separation, depending on the nature and pressure of the gas filling. Fig. 1 shows various electrode arrangements which have been found to work satisfactorily. Figs. 2 and 3 show the variation of anode gap resistance with cathode current and frequency respectively. The gap resistance can be measured directly using an a.c. bridge. It can be seen that

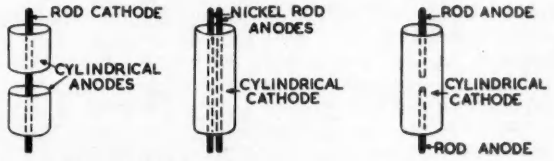


(a) DOUBLE ASSEMBLY VALVE, ROD ANODES



(b) VALVE WITH PLATE ANODES PERPENDICULAR TO CATHODE SURFACE

(c) VALVE WITH PLATE ANODES PARALLEL TO CATHODE SURFACE
This valve was similar in construction to (a), but the nickel rods were replaced by flat anode plates with their flat surfaces parallel to the cathode.



(d) CENTRAL CATHODE
(e) CENTRAL ANODES PARALLEL TO EACH OTHER
(f) CENTRAL ANODES OPPOSITE EACH OTHER

Fig. 1. Various structures for double anode valve

the gap resistance is substantially independent of frequency but varies inversely with the total current through the valve. The apparent increase of resistance at low frequencies is caused by the impedance of blocking capacitors used in the measuring circuit becoming appreciable at these frequencies. Below a current of 10mA there is a rapid increase of gap resistance, but above this current the variation of resistance with current is gradual. The gap resistance is substantially non-reactive, there being no frequency dependent inductive component present such as is normally found in diode electrode arrangements. It is also noise free.

Fig. 4 shows the d.c. characteristics of a typical valve using the electrode arrangement already described and Fig. 5 shows the circuit used to measure the characteristic. The

* *Standard Telecommunication Laboratories, Ltd.*

anodes were controlled by separate h.t. supplies, and these supplies were first adjusted so that the currents in the two anode circuits were equal. The voltage of each supply was then adjusted so that one anode source was raised in voltage by steps of 5 volts, while the other anode source was lowered in steps of 5 volts. The currents in each anode

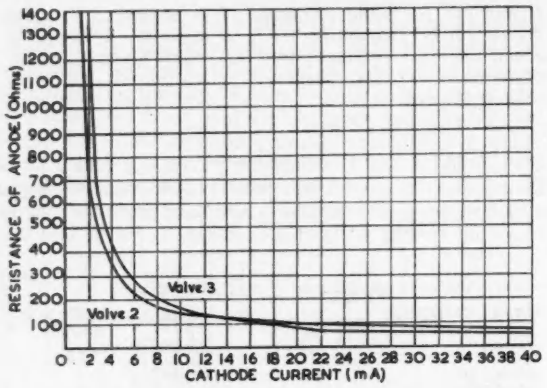


Fig. 2. Variation of resistance with cathode current

Valve No. 2—½ millimetre gap between anodes. 30mm Hg. pressure of neon-argon gas mixture.

Valve No. 3—½ centimetre gap between anodes. 30mm Hg. pressure of neon-argon gas mixture.

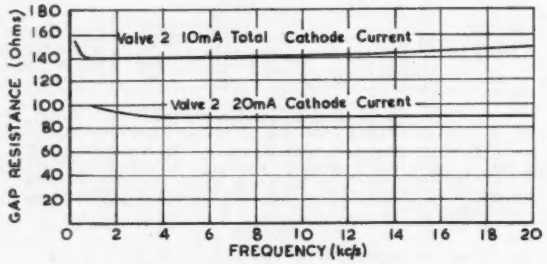


Fig. 3. Variation of gap resistance with frequency

Valve No. 2—½mm anode gap. Neon-argon gas mixture at a pressure of 30mm Hg.

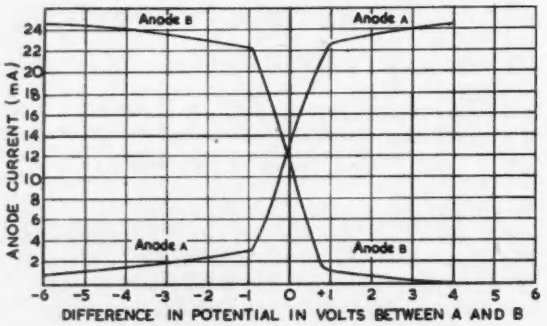


Fig. 4. Anode characteristic of double anode valve

Valve No. 3—½mm anode gap. Neon-argon at 30mm Hg. pressure.

circuit were measured for each 5 volt variation, and the voltage difference between the anodes was also measured. The characteristic shows that about the point where the anode currents are balanced there is a region where a small change in voltage on one anode produces large current variations in the two anode circuits. It is also obvious that as the current in one anode circuit increases, there is a corresponding decrease in the other anode circuit of approximately the same amount, so that the cathode current remains constant. The linearity of the graph in the working region shows that distortion will be negligible. The graph also shows that this electrode arrangement has the important property that a surge of voltage in one anode circuit will not extinguish the discharge so that the valve ceases to operate. Such a surge will merely cause one anode to stop taking current, the whole of the current through the valve being taken by the other anode until the surge has passed. This is a useful characteristic for telephone line operation.

Valves incorporating the double anode electrode arrange-

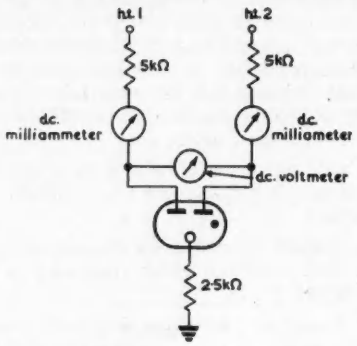


Fig. 5. Test circuit for d.c. characteristic

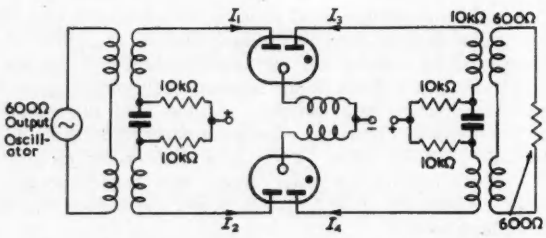


Fig. 6. Use of the double anode valve as a switch directly in the telephone line

I_1, I_2, I_3, $I_4 = 10mA$

ment can be used for speech transmission in a circuit similar to that shown in Fig. 6. The valves are acting effectively as switches in the line. In a 10kΩ impedance circuit the total loss due to a pair of valves acting as one stage is less than 0·2dB.

To enable valves using the electrode arrangement to be switched directly using pulse voltages in the line it is necessary to have stable, reproducible electrical characteristics. For instance, the maintaining voltage, V_m, of all valves should be within the limits of ± 5 volts if V_m is of the order of 100 volts, and the breakdown voltages, V_b, should be within the limits of ± 10 volts if V_b is of the order of 250 volts. It is also necessary to have a large difference between the maintaining voltage and the breakdown voltage of the glow discharge. V_m is controlled by the nature of the gas filling, current density, cathode material and state of the cathode surface. V_b is also controlled by these factors, but in addition it is a function of the product of gas pressure and electrode separation.

During study of the geometrical design factors necessary to ensure a low resistance gap between the joint anodes,

experiments were undertaken to relate gas pressure and electrode separation to gap resistance. This was done by taking a valve with an electrode separation of fixed value and measuring the resistance between the anodes when the valve was still on the pump bench so that the gas pressure could be varied at will. The current in the discharge was kept constant at 20mA. The results for helium are shown in Fig. 7. It shows that there is a sudden sharp increase in resistance when a given pressure is reached for a particular electrode separation. Argon gave similar results. Fig. 8 shows a similar graph for neon-argon-hydrogen gas mixture and here, after the sudden increase to a high value there is a rapid decrease to a fairly low resistance once more. It is interesting that there is normally a blue coloured anode glow on the anode surface when there is a glow discharge in

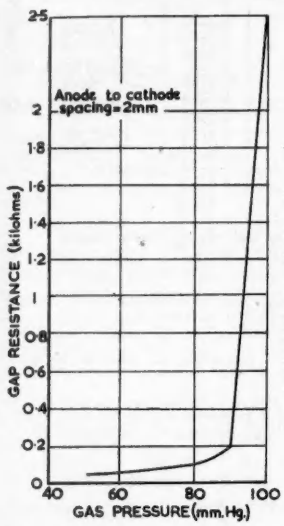


Fig. 7. Variation of anode to anode resistance with gas pressure (helium)

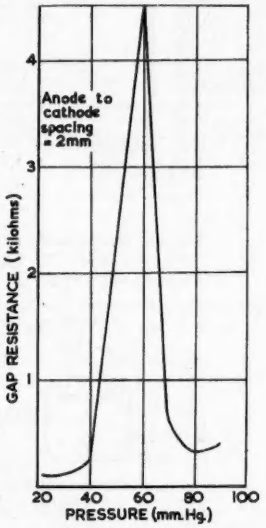


Fig. 8. Variation of anode to anode resistance with gas pressure (neon-argon-hydrogen (9 : 1 : 7))

neon-argon-hydrogen gas mixture and yet this glow is not present at low pressures when a low anode to anode resistance is observed, but appears suddenly when the sharp increase in anode to anode resistance takes place. This argues the sudden formation of a space charge sheath on the anode, because anode glows are formed when a space charge exists in the anode region. Probe measurements confirmed that space charge sheaths do form on the anodes at the pressure at which the gap resistance suddenly increases to high values.

The above results show that the anode-cathode gap values cannot be increased indefinitely in order to secure a high V_b because there is a critical distance at a given gas pressure beyond which a low gap resistance cannot be obtained. However, it was found that this distance was sufficiently great for a large $V_b - V_m$ difference to be obtained while still retaining a low gap resistance if helium was used as a gas filling and the pressure was suitably chosen.

Another requirement when considering pulse breakdown is that the gap shall always break down when a pulse of given amplitude is applied to one or both of the electrodes.

There are two physical phenomena which introduce a time lag between application of a sufficient voltage on the anode to produce breakdown in a gas discharge system and the stable establishment of the discharge. These are called the statistical delay time and the formative delay time.

The statistical delay time is dependent upon the presence of an electron or ion in the gap between the electrodes at a particular instant of time. The ion can be accelerated towards either electrode and produces sufficient ionization in the gas to cause breakdown between the electrodes. Ions are normally present in any gas atmosphere because of ionization by cosmic radiation, but the number of ions present per unit volume in a gas-gap can be greatly increased by irradiating the gas with X-rays or ultra-violet light or by photo-electric effects at the electrodes due to either of these agents or visible light. Thus, by suitable priming, the statistical delay time can be eliminated.

The formative delay time depends upon the time taken for the ion or electron which initiates the discharge to produce sufficient ionization to cause breakdown and produce a self sustaining discharge. This depends upon parameters governed by the pressure and nature of the gas and geometrical dimensions which are normally constant for a given gas-gap, but it is also governed by the voltage applied between the electrodes. Thus, formative delay time cannot be eliminated, but is reduced by increasing the voltage applied between the electrodes to initiate breakdown above the value which will just cause breakdown if applied for a very long time.

Formative delay time necessitates the application of pulse voltages with amplitudes greater than the normal d.c. breakdown voltage of a gas-gap in circuits where pulse techniques are used to initiate the discharge. The difference in voltage between the pulse amplitude required to produce breakdown and the d.c. breakdown voltage is called the "overvoltage". Early measurements upon speech-gap tubes showed that the overvoltage required to produce breakdown depended upon:

(1) History of the cathode (i.e. whether it has been conducting or left idle).
(2) Pulse width.
(3) Light falling on the electrodes; photo-electric effect.

There are several ways in which the photo-electric priming can be produced. An internal priming source can be incorporated in the valve, or an external agent such as an ultra-violet light source can be arranged to prime a bank of tubes. Another method of priming is to introduce a radioactive substance into the valve, so that ionization is produced by radioactivity. The availability of tritium, a weakly radioacitve substance with a half-life of $\simeq 12$ years and radiation energy of <10keV, which can be used with safety within a glass envelope has greatly increased the attraction of this latter form of priming. The advantage of the method is that no electrical power is consumed to produce the priming.

Theory of the Low Resistance Anode to Anode Gap

Probe[2] and other measurements[3] recorded in original published papers have shown that the negative glow is a plasma region, there being high equal concentrations of positive and negative ions here. Concentrations of 10^9 ions/cm^3 have been calculated from measurements made, and Emeleus[4] quotes a figure as high as 10^{11} ions/cm^3. The conductivity of the space between the anodes operating under the conditions outlined in this report is therefore high, and a low resistance might be expected from this consideration. On the other hand, it is difficult to see why a change of one volt at either anode should cause the anode concerned to take all the current formerly being received

by the other anode, which is normally only about 1mm away.

Fig. 9 shows graphs of gap resistance against gap length for an experimental valve containing one fixed and one mobile anode. The electrode assembly was otherwise similar to that of normal valves except that a larger area cathode had to be used, and therefore high total currents were required to cover the whole cathode surface with a glow discharge. At a current of 15mA per anode an irregular curve was obtained. This was because there was a relatively dark patch on the cathode surface between the

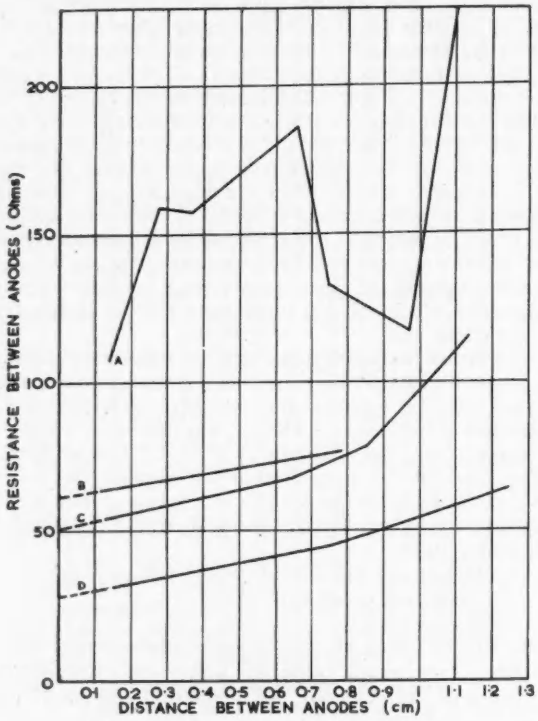


Fig. 9. Variation of resistance with gap length

A—15*mA per anode*
B—20*mA per anode*—*slope* = 2·34 Ω/*mm*
C—20*mA* ,, ,, ,, = 3·0 Ω/*mm*
D—30*mA* ,, ,, ,, = 2·2 Ω/*mm*

anodes, and when the moveable anode was over this area the resistance between the anodes was high, but as soon as the anode moved over a part of the cathode where the negative glow was normal, the resistance of the gap decreased. At the maximum spacing the resistance increased suddenly because this was the edge of the negative glow region, and the mobile anode was moving out of contact with the plasma. The graphs for higher currents show that there is a steady, small increase of gap resistance with gap width, this increase being only a few ohms per millimetre. The slopes of the graphs at the two higher currents are sensibly the same.

The conclusions drawn from the results are that a field theory of the switching action cannot be substantiated, and that a theory on the conductivity of the plasma can only be advanced if some boundary condition at the anodes is postulated to account for the large residual resistance which is obtained for zero length when the graphs are extrapolated.

Probe measurements were next made to elucidate what happens to the plasma potential when one anode is raised and then lowered in potential so that it draws maximum current and then minimum current. A valve similar to that represented in Fig. 10 was used, and the measuring circuit is shown in Fig. 11. The anodes were connected directly to the variabe h.t. sources 1 and 2, and the probe potential was varied by means of a potentiometer supplied from h.t. source 3. The currents in the anode circuits were measured by low resistance milliammeters, and the probe current was measured by an accurate multi-range microammeter. The probe potential relative to earth was measured very accurately with a standard potentiometer, and the same instrument was used to measure the anode voltages

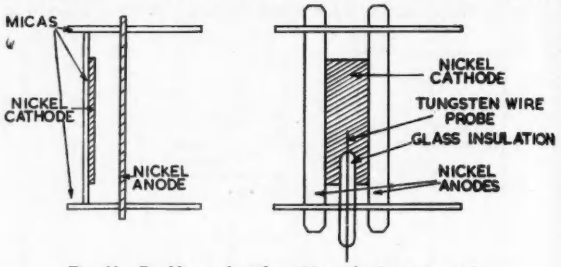


Fig. 10. Double anode valve with probe between anodes

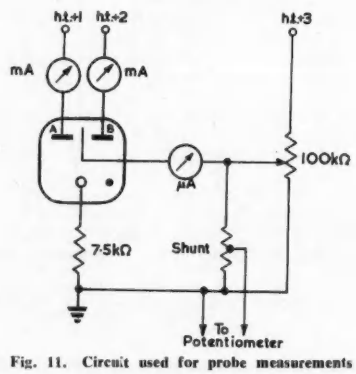


Fig. 11. Circuit used for probe measurements

accurately. Since there was practically no resistance in the anode circuits, the shunt current did not affect the anode voltage when the potentiometer was connected between anode and earth. The probe potential measured by the potentiometer must be corrected for the potential drop across the microammeter.

The probe characteristics and anode voltages were measured (A) with the anode currents balanced at 10mA, (B) when anode A was raised in potential until anode A drew 20mA current and anode B drew zero current, (C) when A was lowered in potential until A drew zero current and B drew 20mA current. Fig. 12 shows the probe characteristics for these three states, and Fig. 13 shows the plots of the i^2/V characteristics for the same states for electron currents above the knee part of the probe characteristics. Langmuir probe theory[1] requires that the i^2/V characteristic should be linear except near the space potential, and from the slope of the line the number of electrons per cm³ of the plasma can be calculated.

RESULTS:

(a) Potential of anode A = 263·2 volts
,, ,, ,, B = 263·12 ,,
Space potential (from graph) = 263·82 ,,

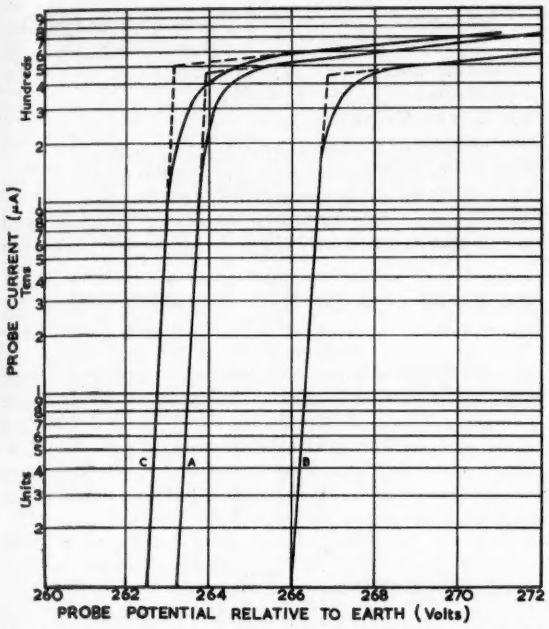


Fig. 12. Probe characteristics for balanced and unbalanced states of anode currents in a double anode valve

(b) Potential of anode A = 266·9 volts
" " " B = 263·24 "
Space potential (from graph) = 266·8 "
(c) Potential of anode A = 258·44 volts
" " " B = 263·04 "
Space potential (from graph) = 263·15 "
Electron temperature (from slope of graphs in Fig. 12) = 1 144°K
Number of electrons per cm³ (from slope of graphs in Fig. 13) = 3·7 × 10⁹

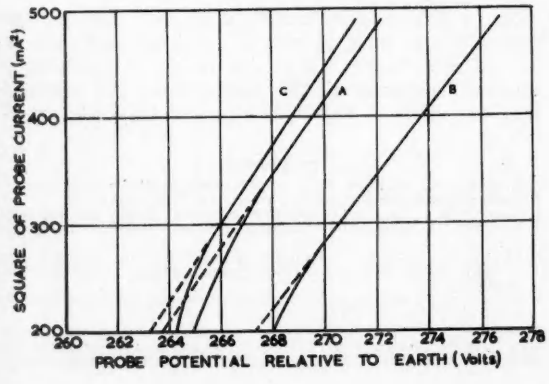
CONCLUSION

It is seen that the space potential appears to be positive with respect to the anode potential in the balanced state. Contact potential difference between probe and anodes is concluded to be the cause of this.

The results now make clear the switching action of the double anode valve. As one anode is raised in potential the plasma potential follows the potential of the highest electrode with which it makes contact and leaves the other anode at a potential which is now negative with respect to the plasma potential, and so this anode takes a smaller electron current. The other anode takes a greater electron current because the h.t. voltage determines what the cathode current shall be, and so the current through the valve remains approximately constant. If the plasma potential rises to a voltage such that the lower potential anode is several volts negative with respect to the plasma potential, then the current to this anode falls to zero, and the other anode takes all the current passing through the valve. If one anode is lowered in potential, the plasma potential remains close to the potential of the other anode since it still follows the potential of the highest electrode with which it is in contact. The anode which is being lowered in potential therefore draws less and less electron current as it goes negative with respect to the plasma potential until the cut off point is reached. The low electron temperature of the space around the anodes shows that the electrons have low energies and therefore a small negative difference of potential between the anode and the plasma will be sufficient to repel the electrons and reduce the electron flow to the anode.

If the anodes are not in intimate contact with the plasma then the above mechanism cannot work, and this explains why a space charge sheath on the anode causes a high anode gap resistance. It also explains why a patchy glow produces a high gap resistance, because the anode over the part of the cathode where the negative glow is absent or of low intensity will have little influence on plasma potential.

Fig. 13. Probe characteristics for balanced and unbalanced states of anode currents in a double anode valve



Practical Valves

MULTIPLE GAP VALVE

For convenience in circuit design it is desirable to have a valve containing a number of gaps, and a valve containing ten gaps is particularly suitable for telephone work. To meet this demand the multiple gap valve shown in Figs. 14 and 15 was devised. The assembly consists of a cylindrical common cathode made of nickel. The surface is divided into ten equal areas by vertical mica partitions which radiate from the axis of the cylinder to make a flush contact with the cathode surface. The partition micas are located in slots cut in the top and bottom micas which close the ends of the cathode cylinder. The anodes, two in each sector, are mounted at a distance of 2mm from the cathode surface, and are located in the end micas. At the centre of the cathode cylinder a vertical tungsten wire is mounted along the axis to serve as a photo-electric primer to all gaps. This priming device was for experimental purposes only, because although it is a simple means of priming, its power consumption is too high for practical purposes.

A number of these multiple gap valves have been made and they have been found to operate satisfactorily in switching circuits. Great care is necessary to keep the cathode spacing constant at 2mm in all ten gaps, because a difference of 0·25mm in this dimension can cause a breakdown voltage difference of 20V. V_m is constant to a few volts within one valve, but over a number of valves this characteristic can vary considerably unless care is taken in processing and ageing. The valves work well under pulse conditions with pulse widths of 100μsec and overvoltages of 40V. There is a difference in the d.c. breakdown before and after a glow discharge, this difference being about 15V. Typical values of parameters for this

valve are:

Breakdown voltage before glowing	= 330V
" " after glowing	= 315V
Maintaining voltage	= 165V
Gap resistance	= 100Ω

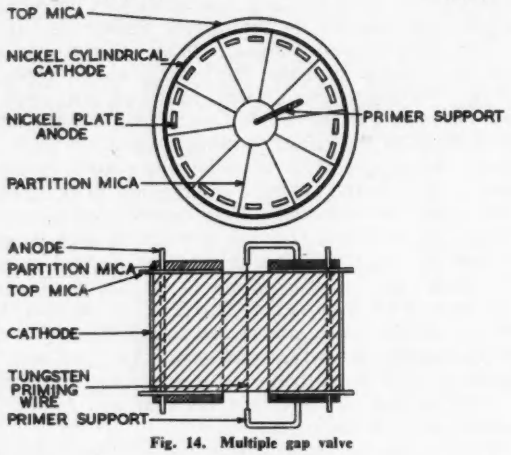


Fig. 14. Multiple gap valve

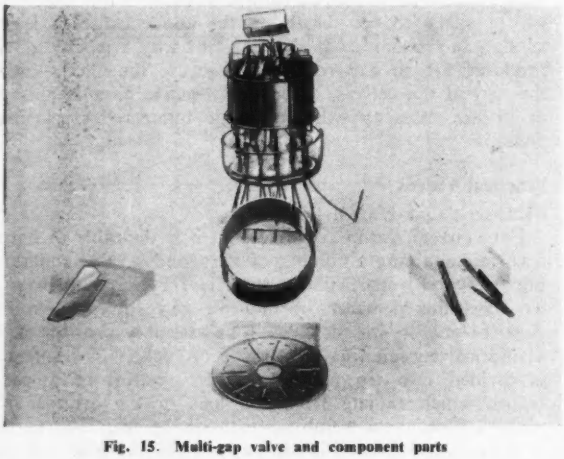


Fig. 15. Multi-gap valve and component parts

Single Gap Valve

This valve is illustrated by Fig. 16. The assembly is cheap and easy to produce, and the pinch seal acts as a convenient mount. Both sides of the cathode are covered by the glow discharge, and this eliminates the need for any micas. However, the anodes must be branched as shown so that they are in contact with the glow plasma on both sides of the cathode otherwise control of the plasma potential is lost and a high gap resistance results. Molybdenum is used as the cathode material because stable, reproducible electrical characteristics can be obtained with this metal if the cathode is thoroughly cleaned by subjecting it to heavy d.c. glow discharge currents. Also, the maintaining voltage of molybdenum cathodes in helium at the pressure used in these valves is 110V, which is several tens of volts lower than the maintaining voltage for a nickel cathode. This lower potential simplifies the circuits used in connexion with the valve. Priming is achieved by the use of radioactive material. Typical characteristics for these valves using helium and neon as gas fillings are:

Helium Filled Valves	
D.C. breakdown voltage	= 240±10V independent of glow history
Maintaining voltage	= 113±2V
Gap resistance	= 100Ω
Neon Filled Valves	
D.C. breakdown voltage	= 280±20V
Maintaining voltage	= 105±2V
Gap resistance	= 200Ω

These figures relate to valves where the effect of wall charges upon breakdown voltage is not directly controlled

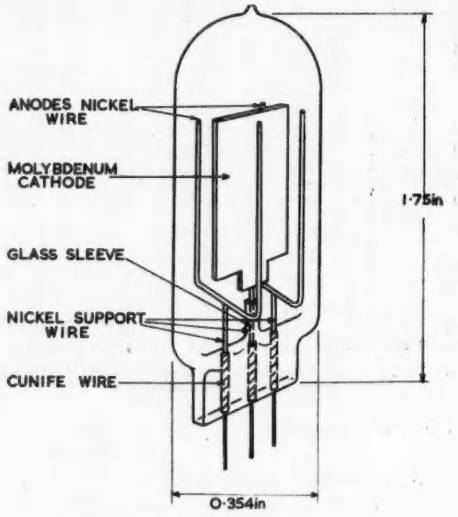


Fig. 16. Unit speech gap valve

by a connexion to the sputtered metal layer in the inner surface of the envelope. Recent work suggests that such control reduces the spread in V_b and can increase the $V_b - V_m$ gap if the potential at which the sputtered layer is maintained is correctly chosen.

Conclusion

The operation and characteristics of the speech gap have now been described. Specific embodiments of the ideas presented have been directed mainly towards the utilization of these devices in telephony, but it is clear that there are many other fields in electronic development where their use would be advantageous. It is hoped that this article may stimulate interest in such development.

Acknowledgments

The authors wish to acknowledge their debt to their colleagues who have assisted in the design and construction of experimental valves and to the management of Standard Telecommunication Laboratories Ltd. and Standard Telephones & Cables Ltd. for permission to publish this article.

REFERENCES

1. Townsend, M. A., Depp, W. A. Cold Cathode Tubes for Transmission of Audio-Frequency Signals. *Bell Sys. Tech. J. 32*, 1371 (1953).
2. Compton, K. T., Turner, Louis A., McCurdy, W. H. Theory and Experiments Relating to the Striated Glow Discharge in Mercury Vapour. *Phys. Rev. 14*, 597 (1924).
3. Van der Pol. A Method of Measuring, Without Electrodes, the Conductivity of Various Points along a Glow Discharge and in Flames. *Phil. Mag. 38*, 352 (1919).
4. Emeleus, K. G. The Conduction of Electricity Through Gases, p. 61 (Methuen & Co. Ltd.).

Patents

Beck, A. H. W., Jackson, T. M., Lytollis, J. British Patent Application 9307/52.
Beck, A. H. W., Jackson, T. M., Lytollis, J. British Patent Application 24260/53.

A Low-Frequency Pulse-Train Generator

By J. E. Flood*, Ph.D., A.M.I.E.E., and J. B. Warman*, A.M.I.E.E.

The pulse generator uses multi-cathode gas-filled counter valves to produce pulses whose make-to-break ratio can be adjusted between 1 : 99 and 99 : 1 in steps of one per cent with an accuracy of one part per thousand. The pulse repetition frequency covers the range 5 to 50c/s, with an accuracy determined entirely by the external oscillator used to drive the pulse generator. The pulses can be sent continuously or in trains of from 1 to 11 pulses with a pause between each train which is adjustable between 66msec. and 4sec.

MULTI-ELECTRODE cold-cathode glow-transfer valves[1-6] provide a useful technique for measuring time intervals by counting cycles of oscillation from a source of known frequency. The counters can be used to control circuits for producing pulses of accurately determined length and pulse repetition frequency (p.r.f.) provided that the frequencies required are within the operating range of the multi-cathode valves. A pulse-train generator using multi-cathode counter valves is described in this article.

The instrument provides pulse-trains whose make-to-break ratio can be adjusted between 1 : 99 and 99 : 1 in steps of one per cent with an accuracy of one part per thousand. The p.r.f. covers the range 5 to 50c/s with an accuracy determined entirely by the external oscillator used to drive the pulse generator. The pulses can be sent continuously or in trains of from one to eleven pulses with a pause between each train which is adjustable between 66msec. and 4sec. These ranges were chosen because the instrument was designed for investigating the performance of circuits and mechanisms used in automatic telephony. The circuit of the instrument is divided into two sections : the pulse generator and the control circuit. Both of these circuits use the Dekatron type of multi-cathode counter valve[2].

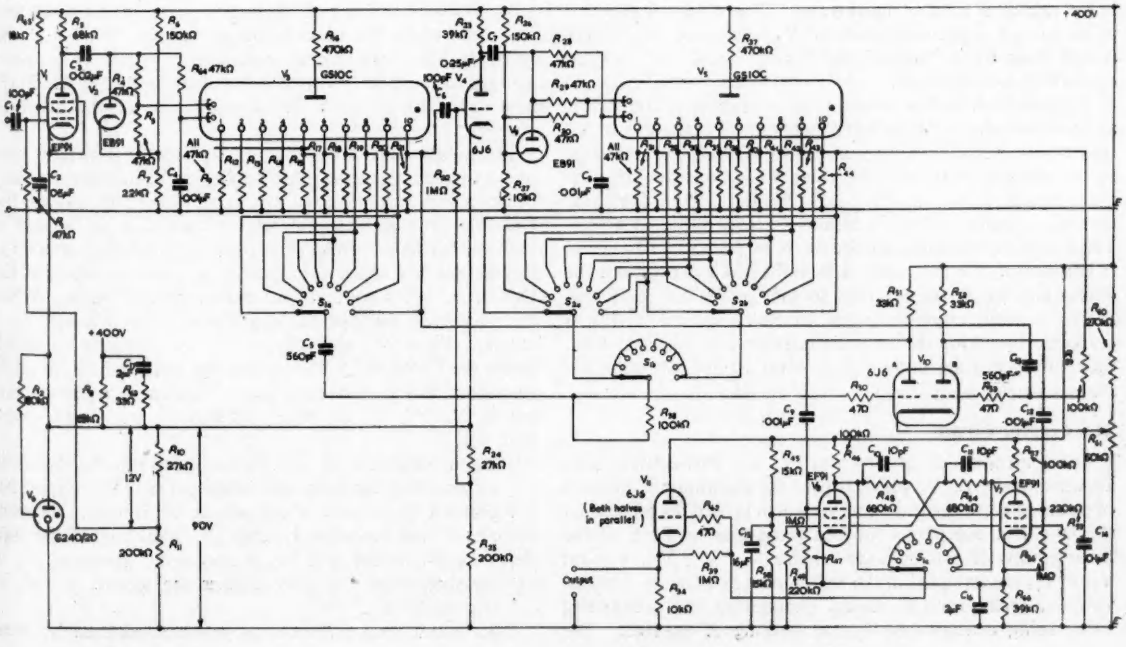
* *Siemens Brothers & Co. Ltd.*

The Pulse Generator

The pulse generator circuit is shown in Fig. 1. Two Dekatron stages are connected in cascade to provide a frequency-division circuit which divides by one hundred. This frequency-divider is driven by an external square-wave generator which is set to a frequency of 100 times the required output frequency. The Dekatron circuits have been found to operate satisfactorily up to a speed of 5kc/s, so reliable operation of the first divider stage sets an upper limit of 50c/s to the repetition frequency of the output pulses. The maximum p.r.f. could be increased by reducing the division ratio, but this reduces correspondingly the number of steps in which the make-to-break ratio can be adjusted. The output pulses are generated by a trigger circuit which is operated by the frequency divider at the beginning of each cycle of 100 input pulses and reset at a subsequent position in the cycle determined by the setting of two switches, thus generating a pulse-train of known make-to-break ratio. The operation of the circuit is described in detail below.

The Dekatrons V_3 and V_5 have driving circuits of a conventional type comprising valves V_1, V_2 and valves V_4, V_6 respectively. Positive pulses drive the control grids of the valves from beyond cut-off into grid current, causing large negative pulses to be produced at the anodes. The negative

Fig. 1. The pulse generator



Pulse at the anode of each valve is applied to two potential dividers ; one divider, consisting of two resistors, applies half the pulse voltage to the first guide electrodes and the second divider, consisting of a resistor and capacitor in series, applies to the second guides a pulse with an exponential rise and fall. Thus at the beginning of the input pulse, the first guide immediately becomes the most negative electrode and the glow transfers to it from the preceding cathode. The potential of the second guide falls, at a rate determined by its *RC* network, to a value more negative than the first guide so that the glow again transfers. At the end of the input pulse, the first guide returns immediately to its positive bias voltage at which it is clamped by the diode. The second guide rises more slowly to the same bias voltage and when its voltage exceeds that of the next cathode the glow transfers to the cathode, thus completing one step forward. Valves V_7 and V_8 form an Eccles-Jordan trigger circuit which is operated by gating circuits formed by the two halves of V_{10} and which drives the cathode-follower output valve V_{11}.

At the beginning of each cycle of operation cathode 10 of V_3 and cathode 1 of V_5 are conducting. Valve V_7 is then conducting and V_8 is biased off, corresponding to the " break " condition. The first input pulse steps the glow in V_3 to cathode 1 and subsequent pulses step the glow further. Each time cathode 10 of V_3 conducts it delivers a pulse to V_4 which steps V_5. When the glow reaches the cathode to which S_1 is set, a pulse is delivered to the grid of V_{10a} by means of C_5. However, this does not cause the valve to conduct unless its bias has already been partly offset by a potential applied to its grid through R_{38} from that cathode of V_5 to which S_2 is set. Thus, only when the cathodes in V_3 and V_5 to which S_1 and S_2 are set are both conducting is valve V_{10a} turned on. The anode of V_{10a} applies a negative pulse to the suppressor grid of V_8, thus changing the trigger circuit from the position corresponding to break (V_8 on) to that corresponding to make (V_7 on). Valves V_3 and V_5 continue to step and when cathode 10 of V_5 is conducting, its rise in potential reduces the grid bias of V_{10b}. When the glow in V_3 also reaches cathode 10, the pulse applied through C_{13} to the grid of V_{10b} turns the valve on. This applies a negative pulse to the suppressor grid of V_7, changing the trigger circuit back from " make " to " break " and the cycle of operations recommences.

A practical difficulty arises in the operation of the circuit as described above. If switch S_1 were set to cathode 1 of V_3, this valve would deliver its pulse before C_5 had time to charge up to the bias voltage from valve V_5. Consequently, the pulse would fail to turn on V_{10a}. This difficulty is overcome by taking outputs only from cathodes 5 to 10 of V_3. Positions 1 to 4 on S_1 use the same cathodes of V_3 as positions 6 to 9 but, to compensate for this, when S_1 is in the first five positions the connexions to S_2 are reversed so that pulses are produced, having a ratio complementary to that required. This is corrected by taking the output signal from V_8 instead of V_7, thus producing an output pulse-train having the required make-to-break ratio.

The Control Circuit

The control circuit is shown in Fig. 2. This contains two Dekatron valves : V_7 which is used for counting the number of pulses to form the train and V_{12} which is used for measuring the length of the pause between pulse-trains. Each of the three groups of cold-cathode triodes V_{13}, V_{14}; V_{15}, V_{16} and V_{17} to V_{19} are arranged in the well known manner[5] so that one valve in each group is always conducting, the conducting valve being extinguished by the striking of another. The control circuit receives pulses from the pulse generator over lead A and receives pulses over lead B from a multivibrator circuit which is not shown in Fig. 2.

When the start key (*KST*) is normal, valves V_{14}, V_{16} and V_{17} are made conducting and the Dekatron valves V_7 and V_{12} each have the glow set to cathode 0. When the start key is thrown, the operating circuits of the valve stages are completed. Contacts KST_1 and KST_2 complete the operating circuit for valve V_9 which provides a delay in starting determined by the time taken to charge C_{32} to the striking voltage of the valve. By adjusting the variable resistor R_{78}, the interval between throwing the start key and the commencement of pulse sending can be varied between a negligible amount and seven seconds. When valve V_9 strikes it reduces the grid bias voltages of the gating valves V_2, V_3, V_4, V_5 and V_{10} from 60V to 10V to enable them to accept pulses. Valve V_{10} is also turned on at its suppressor grid because V_{17} is conducting. The pulses which V_{10} receives from lead B are therefore applied to the drive circuit of Dekatron V_{12} which measures the inter-train pause. Repeated pulses step V_{12} until the glow reaches that cathode to which S_2 is connected and so causes valve V_{18} to strike. This extinguishes V_{17} and feeds a pulse via C_{19} to strike V_{15}. Valve V_{15} extinguishes V_{16} and raises the potential of the guide electrodes and cathodes 1 to 11 of V_{12}, thus resetting the glow to cathode 0.

When V_{17} extinguishes, valve V_{10} is turned off at its suppressor grid to prevent further stepping of V_{12}. When V_{18} strikes, gate V_6 is turned on at its suppressor grid to connect pulses from lead A (via V_2) to the drive circuit of Dekatron V_7 which counts the number of pulses in the train. When the glow steps from cathode 0 to cathode 1 this strikes V_{19} and extinguishes V_{18}. This closes gate V_6 and opens gates V_4 and V_3 by turning on their suppressor grids. V_4 continues the stepping of V_7 with subsequent pulses from lead A and V_3 sends out these pulses by means of the Carpenter relay in its anode circuit. This circuit action avoids any possibility of a distorted first impulse being sent out. If gate V_5 is opened by V_{18} during a pulse on lead A the first pulse fed to V_7 will be clipped, but this pulse is not sent out. In order to avoid clipping of the second pulse (which is the first sent out) when the make-to-break ratio is 99 : 1 and the speed is 50c/s, the circuit comprising V_{17}, V_{18}, V_{19} must operate in 0·2msec. This is ensured by using the G1/371K type valve[5] which has a deionization time of the order of 30μsec.

The pulses which are applied to V_4 in order to drive V_7 are of the opposite sense to those applied to V_3 to drive the relay because they are inverted by valve V_2. This causes the Dekatron to step when the relay releases, i.e. at the end of each output pulse. When the glow in V_7 reaches cathode 2, this strikes V_{16} which extinguishes V_{15} and so prepares the Dekatron V_{12} for counting the next inter-train pause. When the glow in V_7 reaches that cathode to which S_1 is set, V_{17} is struck. Valve V_{17} extinguishes V_{19} and strikes V_{13} which resets the Dekatron V_7 by raising the potential of the guide electrodes and of cathodes 1 to 11. This also closes the gate valves V_3, V_4, V_5 on their suppressor grids and opens gate V_{10}.

Pulses from lead B are now fed via V_{10} to step the Dekatron V_{12} for counting the next inter-train pause. The circuit has completed a whole cycle of operations and is now in the same state as it was immediately after the operation of the start delay circuit except that V_{13} is operated. However, V_{13} is extinguished when the glow reaches the second cathode of V_{12} and strikes V_{14}.

The circuit thus continues to generate, alternately, inter-

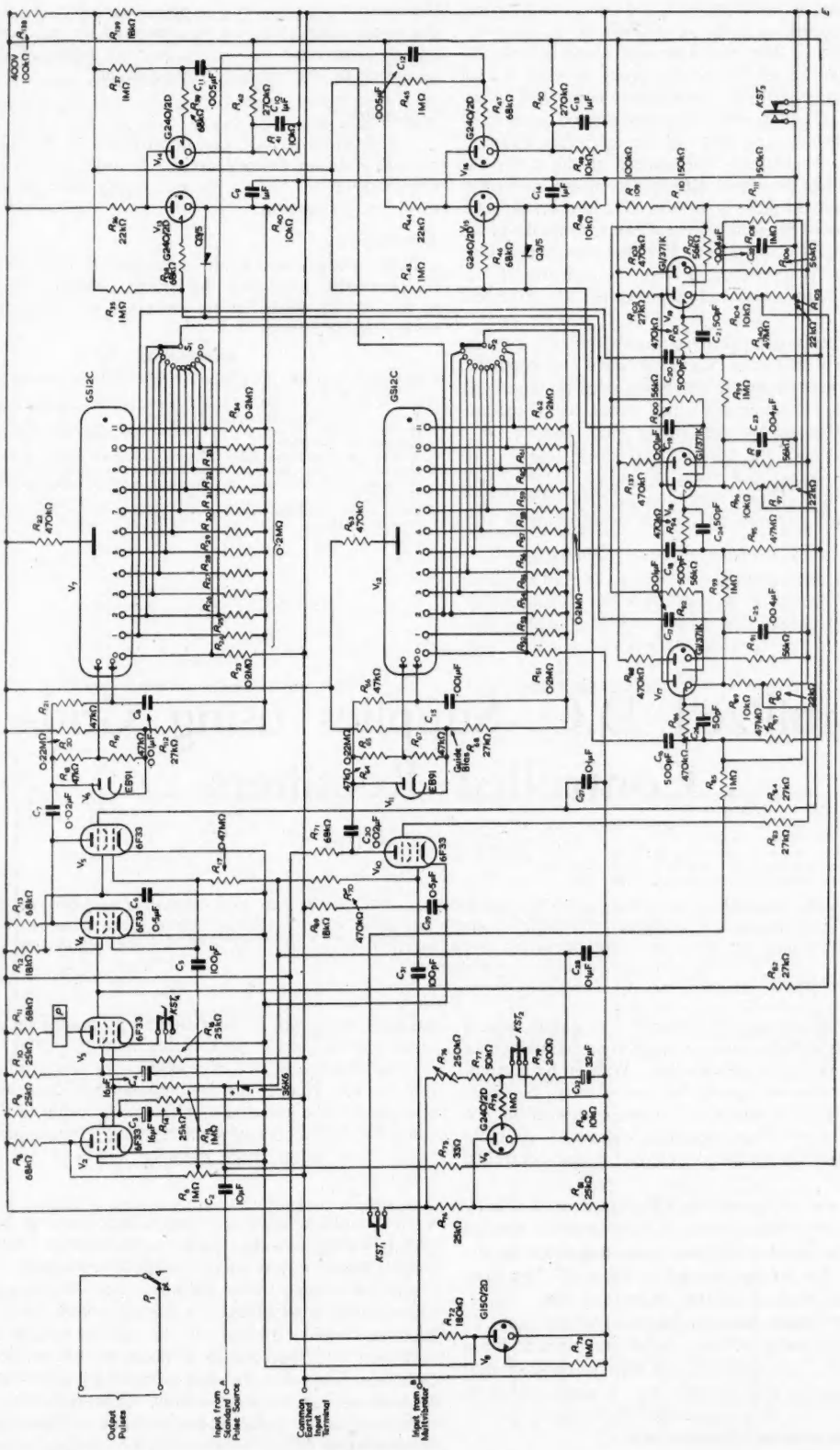


Fig. 2. The control circuit

train pauses of the duration set by S_2 and pulse-trains having the number of pulses set by S_1 for as long as the start key (*KST*) is operated. The multivibrator which drives the Dekatron V_{12} can be set to any frequency between 3 and 30c/s and V_{12} can be set by S_2 to count any number of cycles between 2 and 12, thus producing any desired inter-train pause between 66msec and 4sec. If the inter-train pause is not required to be entirely independent of the p.r.f., the multivibrator can be dispensed with by driving the inter-train pause counter from the pulse-generator. The inter-train pause can then be adjusted between twice and twelve times the pulse repetition period. If switch S_1 is set to its last contact position, so that valve V_{17} is disconnected from the cathodes of V_7, there is no inter-train pause and output pulses are produced continuously.

Oscillograph measurements have shown that the current waveform of the output valve (V_3) repeats the waveform of the pulse generator with negligible distortion, even on the initial pulse of each train. Accurately timed pulses of voltage are therefore available across the anode load resistor R_{11}. The difference between the operate and release lags of the relay, however, causes distortion of pulses derived from its contacts of up to 1msec, depending on their adjustment. If the pulses are required to operate relay contacts and this amount of distortion is not permissible, the distortion due to the relay must first be measured on an oscillograph and then corrected by altering the ratio setting of the pulse generator by the corresponding amount.

Conclusion

The instrument has been constructed in the laboratory and has given satisfactory service. In order to ensure reliable operation of the circuits the h.t. supply must be stabilized to within ± 5 per cent.

Acknowledgments

Acknowledgment is made to Siemens Brothers & Co. Ltd for permission to publish this article. Thanks are also due to Mr. D. M. Bibb for his assistance in constructing and testing the apparatus.

REFERENCES

1. Lamb, J. J., Brustman, J. A., Polycathode Glow Tube for Counters. *Electronics 22*, 92 (November, 1949).
2. Bacon, R. C., Pollard, J. R. The Dekatron : A New Cold Cathode Counting Tube. *Electronic Engng. 22*, 173 (1950).
3. Hough, G. H., Ridler, D. S. Multicathode Gas-Tube Counters. *Elect. Commun. 27*, 214 (1950).
4. Acton, J. R. The Single-Pulse Dekatron. *Electronic Engng. 24*, 48 (1952).
5. Hough, G. H., Ridler, D. S. Some Recently Developed Cold Cathode Glow Discharge Tubes and Associated Circuits. *Electronic Engng. 24*, 152, 230 and 272 (1952).
6. Peck, D. S. Ten-Stage Cold-Cathode Stepping Tube. *Elect. Engng. (N.Y.), 71*, 1136 (1952).

Stabilized D.C. Supplies using Grid-Controlled Rectifiers

By L. Knight*, A.M.I.E.E.

A simple method is described whereby thyratrons can be operated as grid-controlled rectifiers to give a stabilized d.c. supply. Mention is made of some of the special design considerations involved and a typical practical circuit is given together with curves of the voltage regulation obtained.

THE most popular type of stabilized h.t. supply uses a valve in series with the load and regulation is obtained by varying the d.c. resistance of the valve. With an h.t. current of 1 ampere or more this system becomes clumsy. Not only is it necessary to use a number of valves in parallel but the power dissipated by them becomes excessive. A more economical method is to use thyratrons as grid-controlled rectifiers.

The simplest way of controlling a thyratron rectifier is by what is known as the magnitude method of control, so called because the mean anode current is made dependent on the magnitude of a d.c. voltage applied to the grid. The basic operation of this method can be understood from Fig. 1. V_a is the anode voltage during a positive half-cycle and V_c the corresponding value of the critical grid voltage for a typical thyratron. The anode will not start to conduct until V_c falls to the actual grid potential V_g. A small change in the level of V_g will cause a significant change in the firing point and therefore in the mean current.

An alternative method of regulating the output is by phase-shift control. Here an alternating voltage of fixed magnitude is applied to the grid and its phase relationship to the anode voltage varied to control the firing point. Phase-shift control circuits are rather more complex and will not be dealt with here.

A simple magnitude control circuit is shown in Fig. 2. V_3 is a voltage reference tube whose burning voltage is slightly higher than the desired output voltage. In order to keep it conducting a small auxiliary d.c. supply has been connected in series with the main one. V_3 maintains the slider of the potentiometer at a fixed potential above the negative output terminal. If the output voltage falls the thyratron grids become more positive with respect to the cathodes. The valves then fire earlier in the cycle, thus giving a compensating increase in output. Conversely, if the output voltage rises the grids become more negative giving a compensating fall in output.

* *The British Tabulating Machine Company Limited.*

This circuit is not very successful in dealing with variations of mains voltage. If, for example, the mains voltage rises not only does the anode voltage increase, but the critical grid voltage becomes more negative. Both these factors conspire to increase the output voltage and the control circuit is not capable of giving adequate correction. A simple remedy,

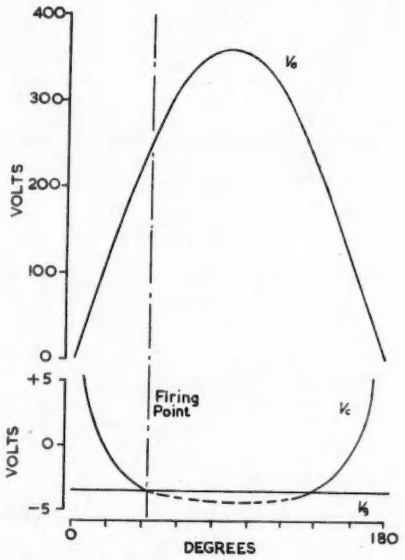


Fig. 1. Voltage waveforms of basic thyratron rectifier

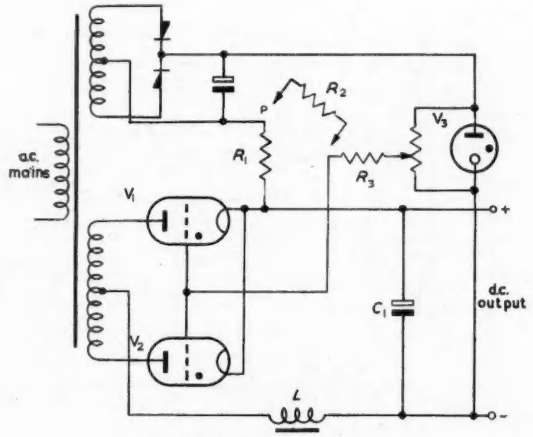


Fig. 2. Basic stabilized supply

described by Trucksess[1], consists of applying to the grids an additional correcting bias which is dependent on the mains voltage. With the circuit in Fig. 2 this can be done merely by adding the resistor R_2. As the mains voltage increases the voltage drop across R_1 will also increase making P more negative with respect to the cathodes. A proportion of this change is now transmitted via R_2 to the grids and causes a reduction in the d.c. output.

If the voltage change which the grids receive via R_2 is too great there will be over-compensation and the output will fall as the mains voltage increases. By suitably proportioning the

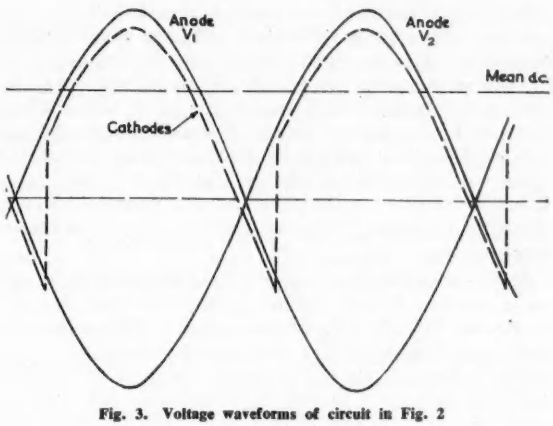


Fig. 3. Voltage waveforms of circuit in Fig. 2

resistor values it is possible to obtain almost perfect compensation over quite a large range of mains variations. The control bias from the reference tube via R_3 then serves to correct only for imperfections in the control from R_1 and for variations in load.

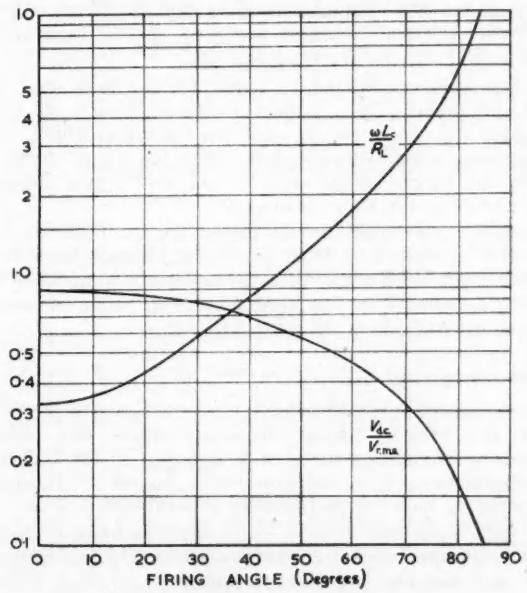
Fig. 2, therefore, constitutes the basis of a simple stabilizing circuit which is capable of handling large mains variations and moderate variations in load. The operation, however, is not quite as simple as may at first appear and it is proposed now to study it in greater detail.

The Smoothing Choke

In particular it is important to examine the action of the choke L which, apart from its obvious function of smoothing

Fig. 4. Variations of critical inductance and d.c. output voltage with firing angle

$\omega = 2\pi$ times mains frequency, L_c = critical value of inductance, R_L = load resistance, V_{dc} = d.c. output voltage + d.c. voltage drop in smoothing choke + voltage drop in one thyratron, V_{rms} = r.m.s. value of anode transformer secondary voltage (one leg to centre tap). It is assumed that ωL_c is large compared with $1/\omega C_1$.



plays another vital role. At the end of each half-cycle the tendency of anode current to cease will cause a back voltage to develop across the choke. This voltage will maintain the cathode potential below that of the anode and, provided that the inductance is high enough, the anode will continue to conduct until the next valve fires. The anode and cathode voltage waveforms with respect to the centre-tap of the anode winding on the transformer will then be as in Fig. 3. It will be noted that the anode-cathode potential of each thyratron just before it fires is nearly twice the instantaneous anode voltage.

If the inductance is dropped below a critical value one valve will cease to conduct before its successor fires. As soon as it ceases to conduct the cathode potential will then become positive with respect to the anode winding centre-tap by the voltage across C_1, that is, the output voltage. Consequently, the anode-cathode voltage of the second valve will be low or even negative at the time it should fire. It will fire late or even fail to fire altogether and the output voltage will fall to a value which allows the valves to fire earlier. The circuit may reach equilibrium with a low output but more often a sustained and rather violent low frequency oscillation will build up.

It is therefore essential to the proper working of the circuit that a choke input filter is used and that the inductance of the choke should be high enough to ensure continuity of current. The critical value of inductance L_c can be obtained from Fig. 4, which is based on curves derived by Overbeck[2]. L_c will be greatest when the firing angle is at its maximum and when the load is lightest. When determining the minimum permissible value of the choke inductance it is advisable to allow a safety factor of about 50 per cent to allow for the effects of voltage drop in the thyratrons and for any unbalance in their charactertistics.

It should be noted that with a very light load the value of the critical inductance is very high. Thus, if the power supply is liable to be operated with no load an internal load resistor should be incorporated, the value of this resistor being chosen to bring the maximum value of L_c to a reasonable value. In cases where there may be considerable variation of the load current the choke will need to have a high inductance at low current and a small inductance at high current. A " swinging " choke will then prove most economical.

Fig. 4 also enables the d.c. output for any firing angle ›
be ascertained. The minimum obtainable firing angle wll usually be just under 10° and the maximum which will normally be required is about 50°. From Fig. 4 it will be seen that this range of firing angles is sufficient to give a range of about $1\frac{1}{2}$: 1 in the value of V_{dc}/V_{rms}.

As the firing angle becomes greater the a.c. ripple on the output increases and better smoothing becomes necessary. As a rough guide it may be taken that with a firing angle of 50° the ripple will be four times as great as with a full-wave diode rectifier giving the same d.c. output.

The Thyratrons

An important consideration is that of which type of valve to use. Mercury vapour thyratrons require that rather exacting precautions be taken with regard to the ambient temperature and to the warming-up period. Thyratrons containing inert gas are therefore preferable.

With these latter types measures must be taken to delay the application of inverse voltage when anode current ceases. If a sufficiently high inverse voltage is reached before deionization is complete, the residual positive ions will be driven into the anode with such high velocities that many will become trapped. This results in clean-up of the gas and produces a marked shortening of the valve life. A limiting value for the product of the rate of decay of anode current and the rate of increase of inverse voltage is usually quoted by the valve manufacturer. Normally, it is possible to keep well within this figure by placing a suitable capacitor and resistor in series from anode to cathode[3]. The capacitor, together with the leakage inductance of the transformer, slows up the rise of the inverse voltage. The resistor damps the tuned circuit thus formed and prevents oscillation.

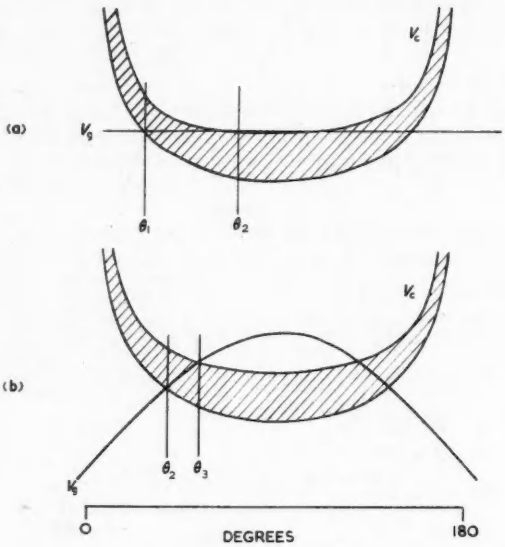


Fig. 5. Effect of adding a.c. to the d.c. bias

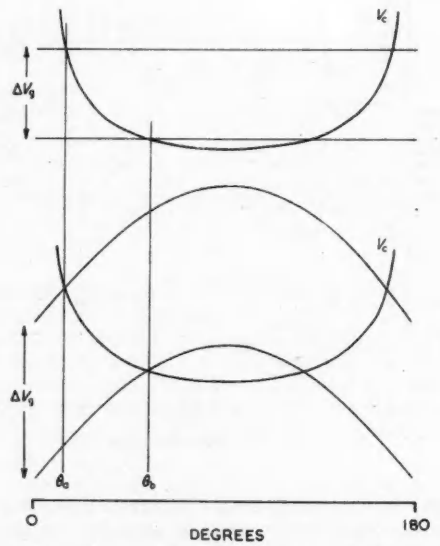


Fig. 6. Effect on sensitivity of a.c. added to the d.c. bias

It has been supposed hitherto that the circuit will behave symmetrically, each valve conducting for 180°. With the circuit given this might be far from the actual case. The grid characteristics of thyratrons are liable to vary quite considerably from one valve to another and to change with age. Fig. 5(a) shows the possible variations in the critical grid voltage curves for a typical thyratron. With a grid bias level V_g the firing angle might be anywhere between θ_1 and θ_2, a range of about 45°. If the two valves in a full-wave circuit had extreme and opposite grid characteristics there would be a marked inequality in the firing angles and in the mean current of each valve.

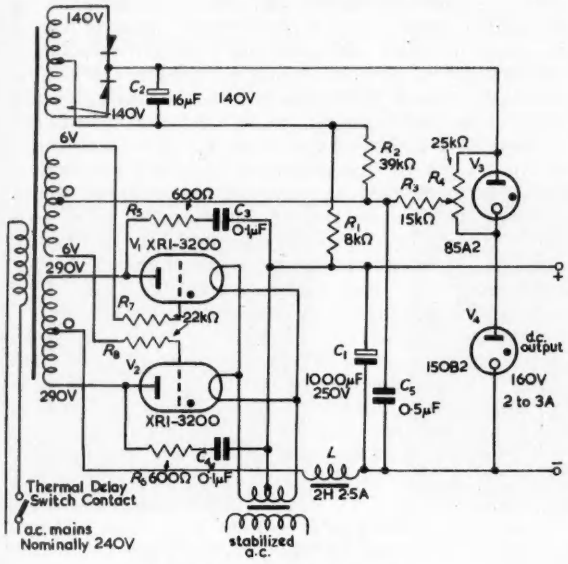


Fig. 7. Practical stabilized supply

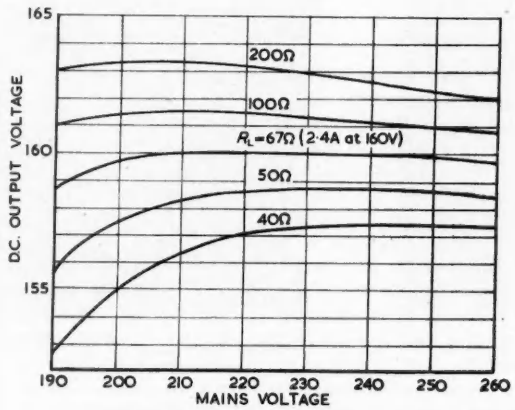


Fig. 8. Regulation of practical stabilized supply

The symmetry can be greatly improved by superimposing a small alternating voltage on to the d.c. bias. Ideally this voltage should lag on the anode voltage by 90° but, providing the firing angle is never to be greater than about 50°, it is almost as effective, and more convenient, to have the grid and anode in phase. Fig. 5(b) shows how the addition of the a.c. reduces the spread of possible firing angles.

Fig. 6 shows the bias variation $\triangle V_g$ required to vary the firing angle between two arbitrary points θ_a and θ_b. It will be seen that $\triangle V_g$ is increased when a.c. is added to the grid bias. In the interests of obtaining the greatest possible sensitivity, therefore, the alternating voltage should not be larger than is necessary to ensure a reasonable firing symmetry.

The thyratron anode current will have approximately a square waveform at all firing angles and thus the transformer design will be similar to that for a normal full-wave rectifier.

A Practical H.T. Supply

As an example of a practical h.t. supply using magnitude control, Fig. 7 gives the circuit of one which was built for an electronic calculator requiring 160V at a current that would remain fairly constant at about 2·4A.

Performance curves are given in Fig. 8. No tests of the long term stability have yet been made but some estimate can be made of what drift to expect. The only components whose characteristics are liable to show any significant variation are the thyratrons. As they age the critical grid voltage curve may be expected to change gradually by one or two volts and the output will then change by approximately the same amount.

The capacitor C_5 gives the control circuit a greater gain at high frequencies and was found to give some assistance in dealing with sudden fluctuations.

It is advisable to keep the filament voltage of any thyratron as close as possible to the nominal value. In the calculator for which this power supply was designed there was already a stabilized a.c. supply for the other valves and this was also used for the thyratrons. The requisite delay in applying anode voltage to the thyratrons was provided by a thermal switch contact in the anode transformer primary circuit.

Conclusion

From experience with power supplies such as described above the author feels that they are very convenient for applications where the load is reasonably constant and the output voltage regulation is not required to be better than about 1 per cent. Although the advantages are most pronounced with high output currents this type of circuit is still attractive at lower currents. Using the miniature 2D21 thyratrons, for example, it is possible to construct a very compact stabilized supply capable of comfortably delivering 200V at 150mA.

Acknowledgment

The author expresses his thanks to the British Tabulating Machine Company Ltd. for permission to publish this article.

REFERENCES

1. Trucksess, D. E. Regulated Tube Rectifiers Using Magnitude Control. *Bell Lab., Rec. 17*, 24 (1938).
2. Overbeck, W. P. Critical Inductance and Control Rectifiers. *Proc. Inst. Radio Engrs. 27*, 655 (1939).
3. Edwards, D. V., Smith, E. K. Circuit Cushioning of Gas-Filled Grid-Controlled Rectifiers. *Trans. Amer. Inst. Elect. Engrs. 65*, 641 (1946).

ADDITIONAL REFERENCES

Grid Controlled Rectifiers Generally :—

4. Jones, R. W. Electronic Control Systems. Ch. 6 and 7. (3rd edition, Chapman & Hall, 1953).
5. Trucksess, D. E. Regulated Rectifiers in Telephone Offices. *Trans. Amer. Inst. Elect. Engrs. 61*, 613 (1942).
   Detailed description of phase-control circuit giving results comparable with circuit described :—
6. A Constant-Voltage D.C. Supply Circuit. *C.R.B. Report* 42/2039 (1942).

C-Band Weather Radar

As aircraft speeds have increased it has become increasingly important for the pilot to have in the cockpit a means of detecting and avoiding unfavourable weather or of navigating safely through it. For this purpose, radar, which in the past decade has become an essential in the study of cloud physics and storm structure, appears to be the answer.

In order to appreciate the importance of radar as a means of weather penetration, it must be understood that the heavy turbulence and hard cores of thunderstorms are usually associated with regions of rapid change in rate of precipitation. These areas of high precipitation gradient give rise to strong radar echoes, and appear on the radar display in terms of varying degrees of brightness. In seeking out these areas the radar beam must penetrate the intervening space in which rain will be falling. It is important that the rainfall in this space should not attenuate the radar signal so much that the response from the critical region is lost. The attenuation experienced is a function of the frequency of the radar and the rate of precipitation. Thus, in heavy rain the range of the radar could be reduced to the point where it would fail to detect the area of turbulence until it was too late for evasive action to be taken.

One of the first extensive flight evaluations of a 3cm navigational radar as a storm detector concluded that "radar was of value," but suggested that "a different, lower frequency would be better suited for this application."

The wavelengths allocated on a world-wide basis for airborne radar under the Atlantic City Regulations are approximately 3cm, 5·5cm and 9cm, and an investigation of the relevant factors at these three wavelengths has been made at McGill University, Montreal.[1] This report shows that intervening rainfall causes attenuation such that the detection range of thunderstorms and heavy turbulence by 3cm (X-band) radars is very seriously limited. Attenuation is appreciable in the case of a 5·5cm. (C-band) radar, but the sensitivity changes more gradually with intervening rain. A 10cm radar can cope with almost any amount of intervening rainfall, but is an unlikely choice because of its greater size and weight and its relatively small angular resolution for a given mirror aperture.

At any wavelength the attenuation suffered is dependent on the product of precipitation rate and the extent of the rain along the line of the radar beam. A frontal line of showers is likely to involve the passage of the beam through several hundred mm.h^{-1} miles of rain—perhaps up to 900.

In the comparison of the relative advantages of C-band and X-band having typical values of transmitted powers and mirror apertures, it was shown[1] that, for amounts of intervening rain up to 200mm.h^{-1} miles, the X-band equipment gives greater ranges than the C-band. With this amount of intervening rain, both wavelengths have a limiting range of 31 miles. As one proceeds to greater amounts of intervening rain, the range at X-band drops off very rapidly, so that with twice the above amount of intervening rain the range is about 7 miles. At C-band, on the other hand, the same 400mmh^{-1} miles of rain only reduces the range to 27 miles—a drop of less than 15 per cent.

The report concludes that—"Sensitivity at 3cm varies very rapidly with the amount of intervening rain, and this rapid variation in itself would lead to uncertainty in interpreting signals. Five hundred mm.h^{-1} miles of rainfall is enough to render 3cm equipment practically inoperative. At a wavelength of 5·7cm attenuation is appreciable but the sensitivity changes more gradually with intervening rain, and the range would never be reduced by more than 30 per cent."

These are considerations of sensitivity. For the same size mirror C- and X-band equipments will differ also in resolution, the shorter wavelength equipment giving a correspondingly narrower beam, with correspondingly higher resolution. But attenuation will introduce distortion into the pictures, altering outlines and casting shadows of nearer showers on more distant ones. Thus, the initially better resolution of the shorter wavelength may well be more than cancelled out by the higher attenuation.

The recommendation for the development of C-band radar, which was the result of the above investigation, led to a debate in the United States as to the relative merits of C-band and X-band. There seemed little argument as to the better penetration of heavy rainfall by the former, but there was some question as to the need for this higher degree of penetration.

An actual evaluation of C-band radar was therefore undertaken by United Air Lines who, in June 1953, installed in a DC-3 aircraft an experimental 5·5cm radar developed for them by the Radio Corporation of America. This was designed to meet operational requirements which called for penetration of 60mm/h rainfall to a depth of 15 miles.

Flight Test Results

The evaluation by United Air Lines, which is covered in detail in their report[2], concludes that C-band radar fully meets the requirements of this specification.

During the tests 40 flights were made totalling 133 hours of flying, 80 hours of which were in the immediate vicinity of thunderstorms. The illustrations shown here were obtained on these flights.

Fig. 1 is a photograph of the radar presentation of an approaching line of storms 100 miles long. The aircraft continued to fly into the storm, and Fig. 2 is the picture at the height of the penetration. It shows how the radar makes it possible for a pilot to pick his way through narrow corridors.

In order to delineate the areas of rapid change in precipitation rate, with which the worst turbulence is associated, circuits were incorporated in the experimental equipment which blank out echoes above a predetermined intensity. This produces on the p.p.i. picture a dark area within the white trace of a storm area, this dark area corresponding to the region of greatest turbulence. This has been called iso-echo contour presentation, the outer contour of the area delineating a line of constant rate of rainfall. Fig. 3 is a photograph of the core of a storm without iso-echo blanking. When blanking is switched on the appearance changes to that of Fig. 4, indicating how the iso-echo technique picks out the area of greatest precipitation gradient. This technique has been found essential for determining those corridors in storm areas which may be safely traversed by an aircraft.

Comparisons between the results given by C- and X-band radars indicated that the X-band gave appreciable attenuation and distortion when flying in or near rainfall rates which were not excessive ; there was no evidence of these on C-band. In addition, the X-band radar tended to show prominently areas of light rain which are of no consequence in aircraft navigation through thunderstorm areas.

Echoes Associated with Hail and Tornadoes

Previous observations with X-band radar had indicated that there were no significant features on the p.p.i. screen to allow hail to be distinguished from rain. In the C-band radar investigation, however, as experience was gained in interpreting the patterns on the screen, it became apparent that fingers or hooked fingers projecting from a thunderstorm echo were characteristic of hail shafts. One of these hooked fingers is shown dead ahead in Fig. 5 and at the tip of this hook grape-size hail was encountered. These were not always observable, but it was the considered opinion of the observers that C-band radar is capable of warning the pilot of the imminence of severe hail four times out of five.

During the time of the C-band radar tests opportunities to make radar observations in the neighbourhood of storms in which tornadoes were reported were relatively few. Although storms that were encountered failed to produce patterns that could be called indicative of tornadoes, the radar was shown to provide indirect evidence which will permit the pilot to avoid these violent storms by exercising ordinary good judgment in avoiding all sharp-edged iso-echo contours and, probably more important, in being highly suspicious of any finger-like projections from such echoes. United Air Lines continued their study during the summer of 1954, with further evaluation of radar detection of tornadoes in mind.

These detailed studies have culminated in the adoption by the Airline Electronic Engineering Committee in the United States of specifications for a 5·5cm weather radar which represents the combined recommendations of the airlines for a unit of optimum performance.

The Radio Corporation of America has now announced an equipment engineered to these specifications, and designated the AVQ-10. It includes many of the features of the set used in the United Air Lines tests with particular emphasis on ruggedness and reliability. The total weight is less than 120lb, and the equipment comprises a stabilized 22in. aerial, transmitter-receiver unit, p.p.i. indicator, control panel, and an accessory unit. The equipment features a specially developed magnetron which, in contrast to previous military magnetrons, was designed with long life and reliable performance as the primary considerations. It has a peak pulse power of 75kW in the 5·5cm band.

In the years to come airborne weather radar will, it is hoped, ensure the dependability and comfort of airline flights as they safely navigate the storms which frequently lie across their routes. If this type of radar lives up to expectation, the risk of blundering into an area of intense turbulence will be minimized, the expensive and dangerous hail damage to aircraft will be eliminated, and long-term savings of time and money will be realized by the reduction of flight-path deviation required by the new method as compared with the wide skirting of complete storms at present necessary.

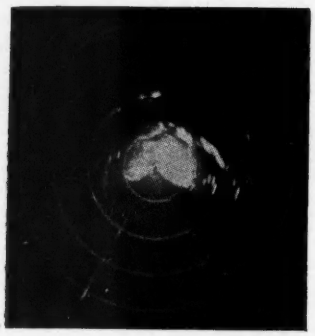


Fig. 1. Approaching line of storms 100 miles long

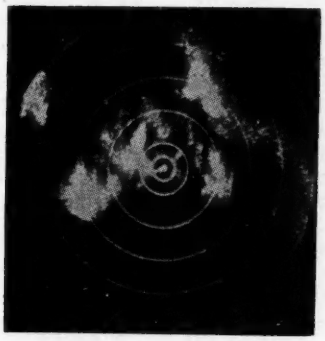


Fig. 2. Height of penetration of storms shown in Fig. 1

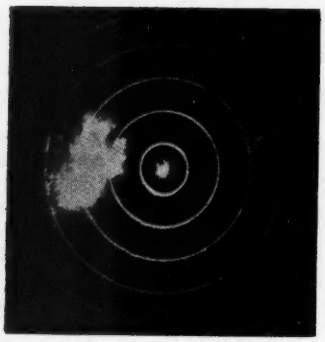


Fig. 3. Core of storm without iso-echo blanking

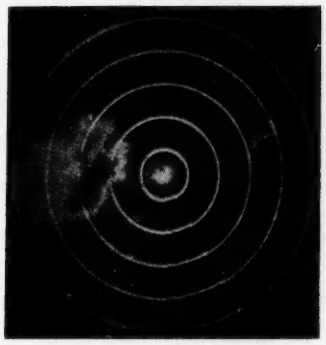


Fig. 4. Core of storm with iso-echo blanking

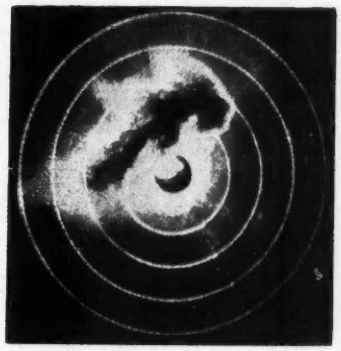


Fig. 5. Indication of hail

REFERENCES

1. Hitscheld, W., Marshall, J. S. Effect of Attenuation on the Choice of Wavelength for Weather Detection by Radar. *Proc. Inst. Radio Engrs. 42*, 1165 (1954).
2. Unpublished Report : "Evaluation of C-Band (5.5 cm) Airborne Weather Radar." United Air Lines, Inc., Denver, Colorado, U.S.A.

A Versatile Output Transformer for Surge Generators

By J. D. Harmer*, B.Sc., and J. R. Howells†, B.A.

The problem arose of designing a transformer which would match the surge generator of a recurrent surge oscillograph to a wide range of load impedance without disturbing the form of the surge. A toroidal transformer is described in which auxiliary windings are used to reduce leakage inductance and so suppress troublesome natural oscillations in the transformer windings. Oscillograph records show the performance of a transformer in which a surge at 2kV, having a front rising in 0·1μsec and a tail of 500μsec duration, is transformed to one of 1 000, 500 or 250V. The form of the surge is accurately reproduced at these tapping points over a wide range of load impedance.

THE response of apparatus to electrical surges can be studied using a recurrent surge oscillograph. This instrument comprises a recurrent surge generator and oscillograph with synchronized time-base for observing the effect of the surge at various points in the apparatus. To be able to test a variety of apparatus with a single instrument, a wide range of time scales is required for the oscillograph time-base. The voltage surge generated requires a steep front when the fast time scale is used, and a long tail for the slowest time scale. The provision of a range of time scales is not difficult. Surges having a front lasting a fraction of a microsecond and any length of tail consistent with the surge repetition rate can be generated using a thyratron.

A more difficult problem is the provision of a transformer for matching the surge generator to the wide range of load impedance which occurs in practice. Leakage inductance and inter-winding capacitance disturb the form of the voltage surge, an effect which can often be compensated by additional filter circuits, but only for a particular load impedance. This article describes a form of matching transformer suitable for surge generators, having many tapping points to which a wide range of load impedance can be applied without impairing the shape of the voltage surge.

The Basic Transformer

An efficient basic matching transformer comprises a single layer toroidal winding for the higher voltage circuit on a ring shaped core. The lower voltage winding can be tapped into this winding if an auto-transformer is suitable, or a separate second winding placed turn for turn over a section of the first. The toroidal form of winding has an intrinsically low leakage inductance, and a single layer winding minimizes capacitance between separate sections of the winding. When a second winding is wound turn for turn upon the first and the start of each is arranged to have a common surge potential, there is no surge voltage between turns of the primary and secondary windings, so that the inter-winding capacitance has no effect.

In its elementary form, the single layer toroidal auto-transformer possesses some leakage inductance, so that the steepness of the front slope of a sharp surge applied to the whole winding is reduced when it appears at a tapping point feeding a resistive load. The presence of stray capacitance, associated with this leakage inductance, is shown by overshoot and there can be subsequent oscillation of the voltage surge at a tapped point not connected to a burden. These unwanted effects could, of course, be eliminated either by confining the use of the transformer to surges with a limited front slope, or by reducing the tail length of the surge which the transformer is required to match, when the core and whole transformer could be made smaller, resulting in a corresponding reduction in leakage inductance and winding capacitance.

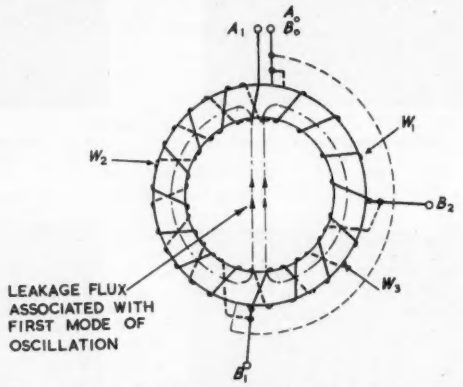


Fig. 1. Arrangement of auxiliary windings on toroidally wound auto-transformer

On the other hand, the following arrangement considerably reduces leakage inductance, without impairing other characteristics, so enabling a single transformer to match surges having the shortness of front and length of tail encountered in recurrent surge measurements.

Leakage Inductance Reduced by Auxiliary Windings

Fig. 1 shows a diagram of a toroidally wound auto-transformer on a ring shaped core. The full winding W_1 is distributed uniformly round the core, commencing at A_0 and finishing at A_1. When a step function surge is applied between A_1 and A_0, the voltage appearing at any tapping point on W_1 (such as B_1 or B_2) will be a proportionately reduced copy of the surge together with oscillating components due to distributed inductance and capacitance of the winding. For a uniform winding, the possible modes of oscillation are such that the voltage distribution along W_1 is approximately sinusoidal, having antinodes at A_0 and A_1. The voltage distribution of the first mode is thus a half sine wave having a node at the centre tapping point B_1. The second mode is a full sine wave having nodes at the quarter (B_2) and three-quarter tapping points.

* *Formerly British Thomson-Houston Co. Ltd.*
† *British Thomson-Houston Co. Ltd.*

The first mode of oscillation can be eliminated by reducing the leakage inductance associated with this mode. The magnetic flux associated with the inductance flows round the core from A_0 to B_1, returning across the air space in the centre of the ring from B_1 to A_0, and from A_1 to B_1 round the other half of the core, returning across the same air path, as shown in Fig. 1. This flux is eliminated by an auxiliary winding W_2* having half the number of turns of the full winding, which starts at B_1 and is wound in the reverse direction from, but turn for turn upon, the full winding up to A_1. The start of W_2 is connected to B_1, and its finish to A_0.

This auxiliary winding W_2 has no effect upon the main flux circulating in the core, since it is effectively a half winding similar to A_0B_1, and in parallel with it. But it presents a closed circuit to leakage flux associated with the first mode of oscillation, and therefore diminishes this flux and discourages the associated oscillation. A step function surge applied to A_1 is by this means more faithfully reproduced at half its value at B_1.

The same principle of using an auxiliary winding can be applied to the remaining section of the winding several

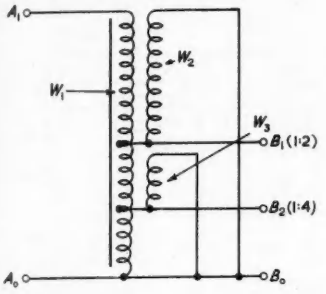


Fig. 2. Connexion of auxiliary windings on auto-transformer

times in succession to overcome the higher order modes. This enables transformer ratios up to 2^n to be obtained, where n is any integer up to the number of auxiliary windings applied. A second auxiliary winding W_3 is shown applied over a quarter of the full winding in Fig. 1. It extends from and is connected to the quarter tapping point B_2, up to B_1, where it is connected to A_0. Fig. 2 shows the method of connecting the auxiliary windings more clearly.

The description just given is for a step down transformer having ratios 1:2 and 1:4. The same arrangement can be used in reverse as a step up transformer having ratios 2:1 and 4:1.

Figs. 1 and 2 show only two auxiliary windings for clarity. The transformer described in the following paragraph had three auxiliary windings, permitting three tapping points on the full winding.

A Transformer for Surges of 2kV

A transformer has been constructed which will transform surges of 2kV having a front rising in 0·1μsec and duration of 500μsec to surges of 1 000, 500 or 250 volts. It faithfully reproduces the form of the applied surge for any load down to an impedance of 1·5kΩ referred to the 2kV winding (i.e. 375Ω at 1kV, 94Ω at 500V, or 24Ω at 250V).

The core is of crystalloy, a ring 5in diameter and cross-section 4sq.in, having an air-gap of 0·001in.

As little insulation as possible is used to keep the wires close together and to the core, in order to minimize leakage inductances. For this reason, thermex insulated copper wire is used, and the whole winding impregnated with a solventless varnish of the polyester type—a voidless insulation permitting high electrical stress without corona discharges.

The core is covered with 0·01in thick elephantide bound with two layers of glass tape 5mil thick. The main winding comprises 464 turns of 32 s.w.g., tapped at 58, 116 and 232 turns. Over this is wound turn upon turn in the reverse direction three auxiliary windings of 58, 116 and 232 turns each, connected in the manner described in previous paragraphs. Before applying the auxiliary windings, strips of thin insulating film of a plastic material compatible with the polyester impregnation were placed over the edges of the toroidal main winding. The completed windings were

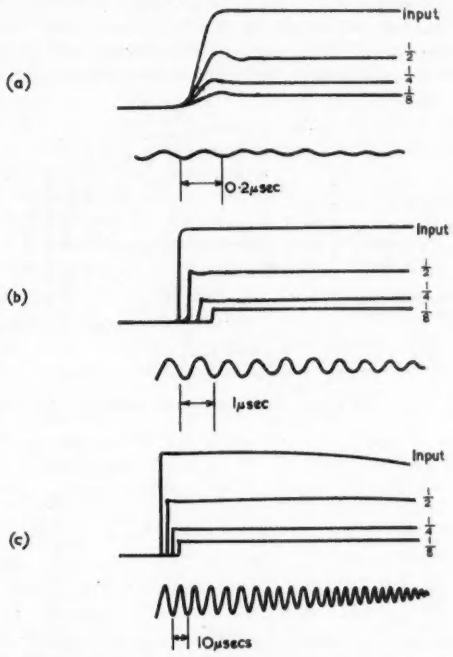


Fig. 3. Oscillograph records of surge appearing at $\frac{1}{2}$, $\frac{1}{4}$ and $\frac{1}{8}^{th}$ tapping points not connected to any burden

then covered with two layers of glass tape, and impregnated under vacuum.

Oscillograph records of the input and output surges at the half, quarter and eighth tapping points on open circuit are shown in Fig. 3. The record in Fig. 3(a) has a fast time-base, and shows how the rise time of the front is preserved without exciting much oscillation. Fig. 3(c) is a record with slow time-base, showing the duration of the tail. In each record, the trace at successive tapping points was moved horizontally to the right to separate the surge starting points and so show the front rises more clearly.

The front rise time of 0·1μsec and the tail duration of several hundred microseconds shown in the records of Fig. 3 were maintained for all load conditions described in the specification.

Acknowledgments

The authors wish to thank Mr. L. J. Davies, Director of Research of the British Thomson-Houston Co. Ltd., for permission to publish this article.

* *British Patent Application 866/53.*

Wide-Range Operation of Grid-Controlled Rectifiers

By D. H. McEwan*, B.Sc., A.M.I.E.E.

A method of controlling thyratron conduction over a wide range from a d.c. control signal is described and the steady-state characteristics of a d.c. power amplifier employing this method of control in a bi-phase rectifier circuit are discussed and experimental results given.

THE use of controlled rectifiers of the thyratron type as a means of obtaining a variable unidirectional current from an a.c. supply is now common in many control applications and offers certain advantages over machine amplifiers, particularly with regard to speed of response.

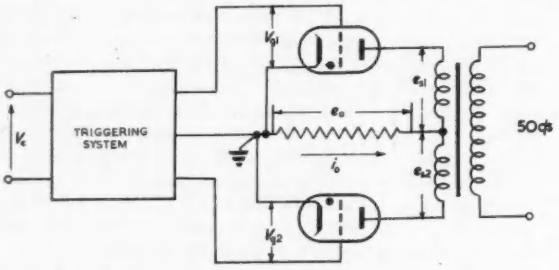


Fig. 1. Basic arrangement of bi-phase circuit supplying resistive load

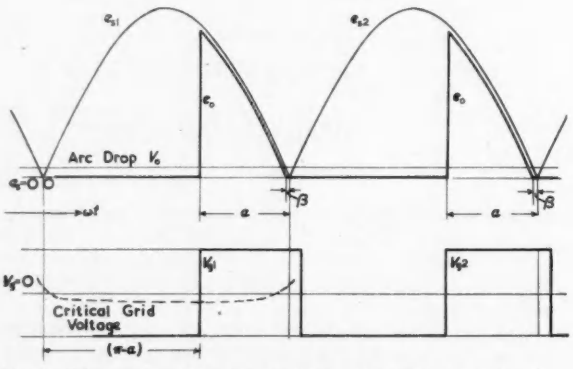


Fig. 2. Trigger voltage V_g and load voltage e_o for conduction angle α in system of Fig. 1

The comparatively high voltage rating of most thyratrons suitable for power control purposes allows good forcing action to be obtained when used as elements in a servo system, and for a given a.c. supply e.m.f. the maximum forcing action will be obtained if the output from the rectifier system is continuously variable from zero up to the maximum possible value as a function of the control signal, which is very often a d.c. "error" signal of small magnitude.

In the course of work carried out on servo systems employing controlled rectifiers, a power amplifier was required in which the conduction angle α (Fig. 2) could be controlled over as wide a range as possible by a signal V_s (Fig. 1) varying over a range of a few volts d.c.

It was decided to investigate the possibilities of a method of control based on the "grid-leak" system which has been used on mercury-arc rectifiers[1]. The "variable-leak" method of trigger voltage control which was developed, is described in the section that follows and has been in use in an experimental thyratron amplifier for a considerable period.

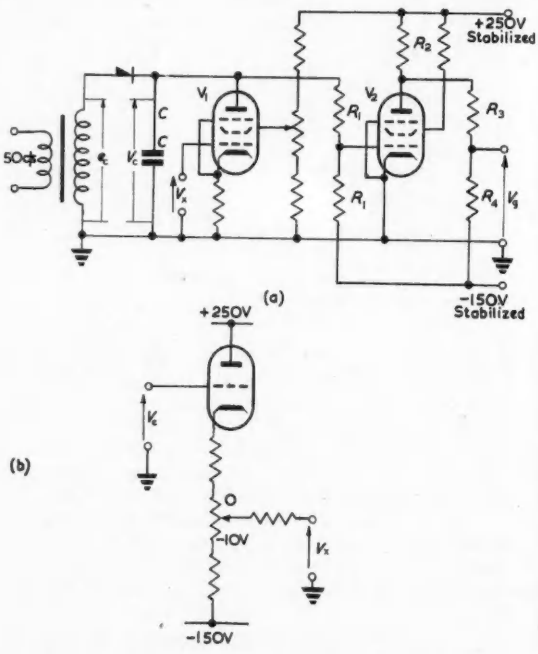


Fig. 3(a). Trigger control (one phase); (b) zero adjustment

Triggering System

To control thyratron conduction, a grid-cathode voltage V_g is required which remains below the critical value up to the point in the positive half-cycle of anode supply e.m.f. e_s at which conduction is required, rising rapidly above the critical grid curve at this point (Fig. 2), a rapid rise being desirable in order to prevent variations in the striking point due to variations in the control characteristics of the thyra-

* *Queen Mary College, University of London.*

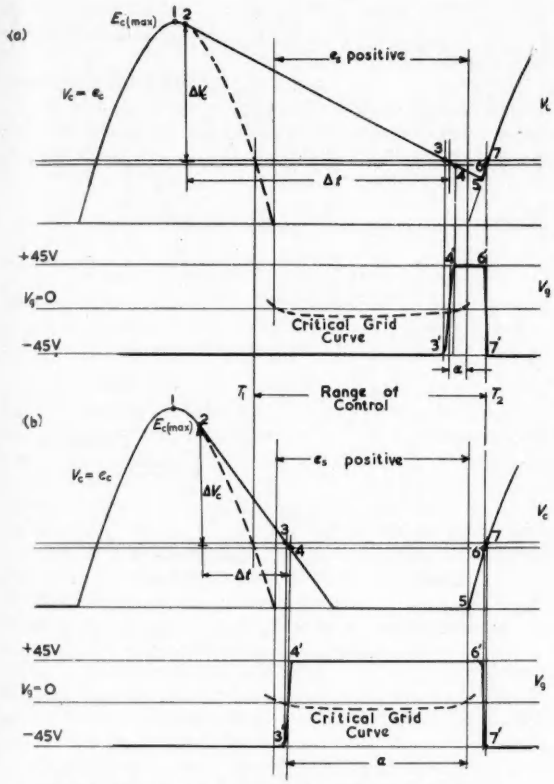


Fig. 4. Waveforms for (a) small, (b) large conduction angles

tron. A short trigger pulse is often used since V_g need exceed the critical value only long enough for ionization to occur, but in a system designed for values of α up to 180° pulse triggering in the range of α from 90° to 180° may give undesirable results when supplying an active load such as the armature of a d.c. motor in a feedback system. The form of the voltage used is as shown in Fig. 2, crossing the critical grid curve at $\omega t = (\pi - \alpha)$ and remaining above the curve slightly beyond $\omega t = \pi$.

In order to vary α as a function of V_e and V_x, the latter is used to control the rate of discharge of a capacitor C (Fig. 3(a)), charged during the appropriate half-cycle through a half-wave rectifier and auxiliary transformer, the secondary e.m.f. e_c of which is 180° out of phase with the anode supply e.m.f. e_s of the corresponding thyratron. Referring to Fig. 4, C is charged to a peak voltage $V_{c(max)}$ at the point 1 and is subsequently discharged almost linearly by the pentode V_1 at a rate dependent on the control voltage V_x. When V_c falls below +150V, valve V_2 begins to cut off and the output voltage to the thyratron grid rises rapidly from a negative limit well below the critical grid voltage curve to a positive limit well above it, the limits being fixed by the values of resistors R_2, R_3, R_4. The actual rate of rise of V_g depends on the rate of fall of V_c and the cut-off characteristics of valve V_2, the rise being sharper for large values of α, since the slope of the V_c curve is greater for this condition.

Figs. 4(a) and 4(b) show the approximate conditions for α in the region of zero and 180° respectively. The capacitor voltage V_c follows the e_c curve to the point 2 beyond which de_c/dt has a greater (negative) value than dV_c/dt as determined by the current through valve V_1. C then discharges almost linearly to 3, V_g rising through the triggering value during 3-4 and remaining at the upper limit from 4 to 6, at which point V_c has again risen sufficiently to allow V_2 to begin conducting, and V_g drops sharply to its lower limit. The rise in V_g can be made to occur at any point in the range $T_1 - T_2$ by suitable variation of the control voltage V_x.

The oscillograms of Fig. 5 illustrate the process described above, showing V_c and V_g for successively greater values of V_x. The traces on the double-beam oscillograph were set initially so that the points 3 and 3′ of Fig. 4, were coincident, no further adjustment being made for subsequent exposures. Oscillograms 3 to 12 cover the range of α from 0 to 180°, the rise of V_g in 1 and 2 occurring beyond $\omega t = \pi$, where the anode supply e.m.f. e_s is negative and conduction does not normally result unless the load is such as to make the net anode-cathode p.d. sufficiently positive. The curvature of the V_c decay line shown on the oscillograms is due largely to the shunting of capacitor C by the input resistance of the oscillograph d.c. amplifier.

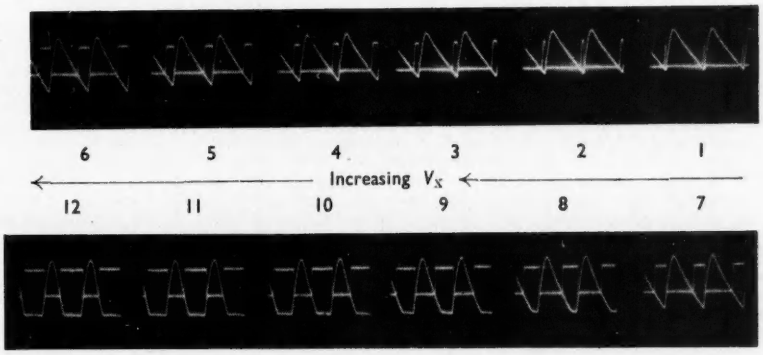
The control characteristics can be readily estimated on the basis of Fig. 4. Assuming a steady capacitor current i_x, its value for a particular conduction angle α is $C.\Delta V_c/\Delta t$, ΔV_c and Δt being found for each value of α by drawing the lines 2 to 4 tangential to the e_c curve. The relationship between α and i_x calculated for three values of $V_{c(max)}$ using a 0·1μF capacitor and supply frequency 50c/s is shown by the curves of Fig. 6(a). The relationship between α and V_x will be of the same general form, the extent of the deviation depending on the variation in the transconductance of valve V_1 over the range of discharge current.

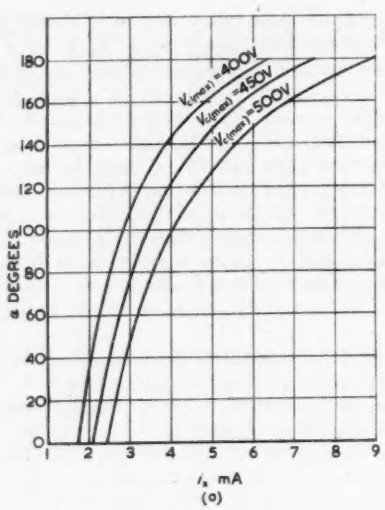
In the trigger circuit as used in the power amplifier, the control voltage V_x is obtained from a cathode-follower stage (Fig. 3(b)) which allows the output to be adjusted to zero by means of the potentiometer, for zero input V_e to the amplifier.

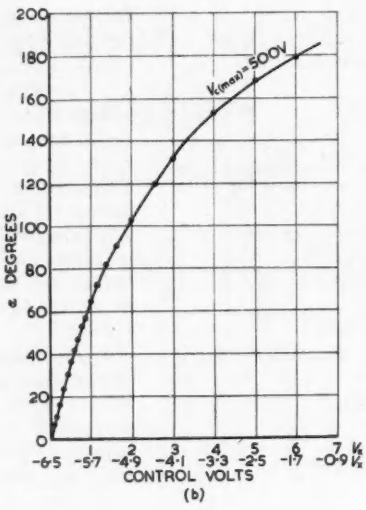
The measured relationship between α and V_x or V_e obtained from oscillograms of the p.d. across a thyratron when supplying a pure resistance load, is shown in Fig. 6(b).

In the section that follows, the steady-state characteristics

Fig. 5. Oscillograms showing effect of varying the control voltage V_x







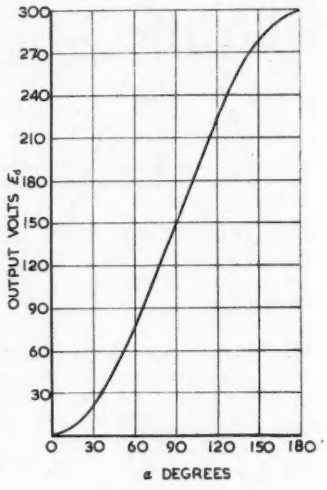
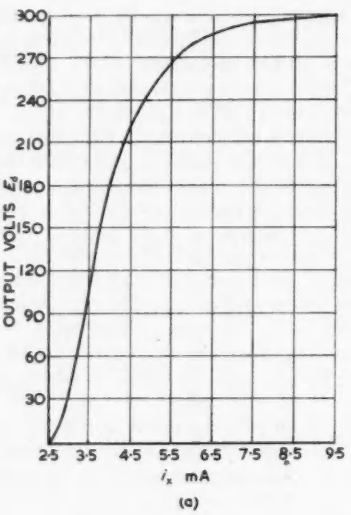


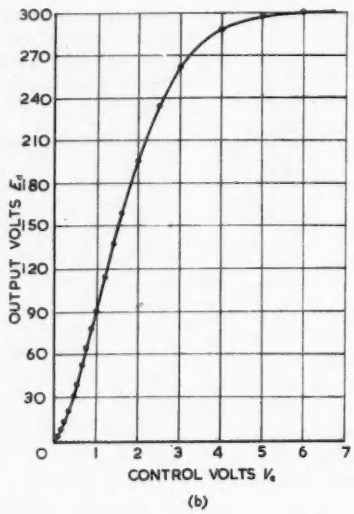
Fig. 6 (top left). (a) Calculated α/ix characteristics
$(0{\cdot}1\mu F,\ 50c/s)$
(b) measured α/V_e characteristic

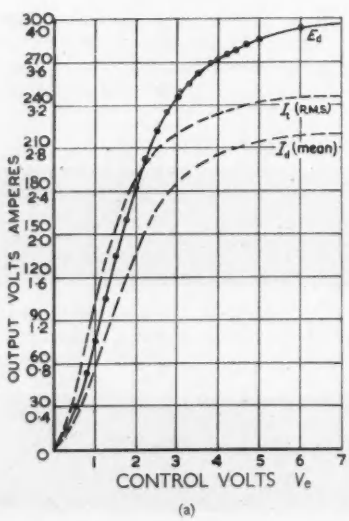
Fig. 7 (top right). Calculated E_d/α characteristic
$(E_s = 350V$ r.m.s., $V_o = 15V)$

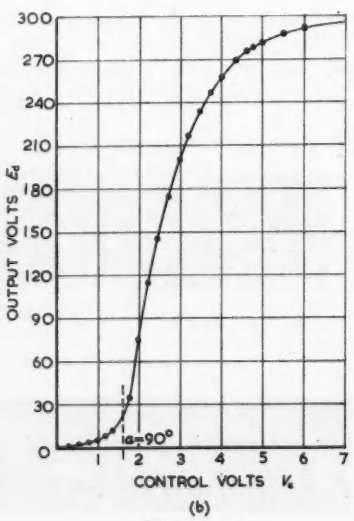
Fig. 8 (left). (a) Calculated E_d/i_x characteristic
$(E_s = 350V\ r.m.s.,\ V_{c(max)} = 500V)$
(b) measured E_d/V_e characteristic
$(E_s = 350V\ r.m.s.,\ V_o \simeq 15V,$ *high resistance load*)

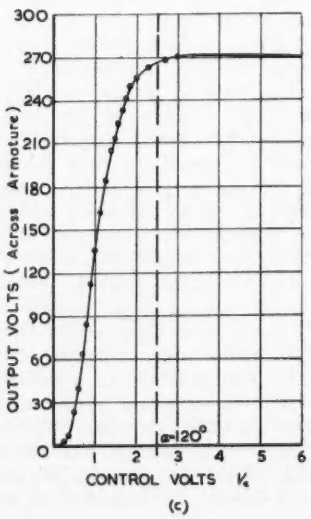
Fig. 9 (below). (a) Measured characteristics, resistance load $\simeq 100\Omega$
$(E_s = 350V\ r.m.s.)$
(b) measured characteristic, highly inductive load
$(R \simeq 100\Omega,\ L \simeq 20H,\ E_s = 350V)$
(c) measured characteristic, motor armature load
(230V d.c. shunt motor, armature resistance $= 16\Omega$. *No load current* $0{\cdot}5A$, $E_s = 240V$ *r.m.s.)*











of the amplifier are estimated and compared with the measured values.

Amplifier Characteristics

In a bi-phase controlled-rectifier system feeding a non-inductive resistance load from a sinusoidal supply e.m.f. of peak value $E_{s(max)}$, the mean output voltage E_d is given by:

$$E_d = 1/\pi \int_{\pi-\alpha}^{\pi-\beta} (E_{s(max)} \sin \omega t - V_o)\, d\omega t$$

$$= E_{s(max)}/\pi\ (\cos \beta - \cos \alpha) - V_o\ (\alpha - \beta)/\pi \quad \ldots\ldots\ (1)$$

where V_o is the arc drop, assumed constant, and $\beta = \sin^{-1} V_o/E_{s(max)}$ as in Fig. 2. If $E_{s(max)}$ is much greater than V_o, expression (1) simplifies to:

$$E_d = E_{s(max)}/\pi\ (1 - \cos \alpha) - V_o\ \alpha/\pi \quad \ldots\ldots\ (2)$$

Fig. 7 shows the relationship between E_d and α for a system in which $E_{s(max)} = 350\sqrt{2}$ and $V_o = 15$V, calculated from equation (2). Using Fig. 7 and the α/i_x curve for the particular value of V_c employed (500V) the estimated E_d/i_x characteristics of Fig. 8(a) were obtained. This indicates the form of the E_d/V_x relationship to be expected, and may be compared with the measured characteristics of Fig. 8(b), obtained with the amplifier supplying a high resistance load of negligible inductance. The α/V_e relationship was also checked from these results and found to be in good agreement with that shown in Fig. 6(b).

The output/V_e characteristics (a) with a resistance load of approximately 100 ohms and mean load currents up to approximately 3A, are shown in Fig. 9(a). The thyratrons and supply transformer used were such that a maximum mean output current of 5A at 300V could be obtained.

The steady-state characteristics of the amplifier supplying (b) a highly inductive resistance load and (c) a d.c. motor armature load, are shown in Figs. 9(b) and 9(c) respectively and are in agreement with the values calculated on the basis of the α/V_e relationship given by the triggering system. It is noticeable that in (b), the output does not vary with V_e to any great extent in the range corresponding to α values from zero up to about 90°, since in this range, the load current is discontinuous, and the high inductance prohibits the rapid variations in instantaneous current possible with the previous type of load. This does not imply that no benefit is gained by having the conduction angle α controllable down to zero, since with this type of load, current decay can be assisted by invertor action, and an improved transient response obtained with the wider range of control of α.

In case (c) with the amplifier feeding the armature of a separately excited motor, Fig. 9(c) shows the E_d/V_e relationship with the motor on no load, when it is seen that the main variation in output occurs for values of V_e in the range corresponding to α values from zero up to approximately 120°. Again improved transient performance will be obtained in a servo system if α is variable over a wider range, since with the armature stationary, maximum current and torque will be obtained only if $\alpha \simeq 180°$.

Conclusions

The method of trigger voltage control employed gives variation of the conduction angle α over a range of approximately $-10°$ to $+200°$ as a function of the controlling voltage V_c, the form of the control being such that when applied to a thyratron amplifier feeding a resistive load, the mean output voltage is a reasonably linear function of V_c, from zero up to approximately 80 per cent of the maximum value, the average voltage gain obtained in the present case being of the order of 100. The system was developed primarily for investigating transient and stability conditions in a thyratron feedback amplifier controllable over the full range, but it is felt that there may be industrial applications where the method could be considered as an alternative to the more established methods of thyratron control from a d.c. signal.

Acknowledgments

The experimental work was done in the Department of Electrical Engineering, University (now Queen's) College, Dundee, and acknowledgment is made to Professor E. G. Cullwick for the use of apparatus in the Department, and to my father, Mr. W. R. McEwan, for much valuable assistance and advice.

REFERENCE

1. Rissik, H. Mercury-Arc Current Converters.

New Marconi Training College

As announced in our December issue the new Marconi College, construction of which began in 1953, is now completed. Entirely new lecture, tutorial, laboratory and administrative accommodation is now contained under one roof, and provides every facility for technological training in the field of electronics for nearly one hundred students and residential accommodation for fifty.

The College now possesses two lecture rooms, ten laboratories, a workshop, a drawing office school, a technical library and a quiet room, in addition to teaching staff rooms where personal tutorials and group discussions take place.

Most of the students are either the Company's own graduate engineers and student apprentices, or nominees of overseas Governments, public bodies or clients of Marconi's Wireless Telegraph Co. Ltd. Private fee-paying students are only accepted after these priority demands have been met.

Main courses in Radio Engineering, Radar Engineering, Industrial Electronics and Television Engineering form the backbone of the College's activities. These courses are of approximately five months' duration and each course concentrates on developing the ability of the student to appreciate in detail the performance, design and measuring techniques involved in the particular circuits and systems. In many cases students need to build up their initial knowledge of the fundamentals of electronics before joining a five months' Engineering Course, and they take a preliminary course for ten weeks. Training on specific equipments is becoming a major responsibility of the College, and a number of short duration courses are already available. These are required mainly by those from overseas who will have the responsibility of maintaining and possibly installing such equipments in their own countries.

Tuition is at an advanced level, the ideal qualifications for admission being a university degree in communications or electronics, although a degree in science, engineering or mathematics, or equivalent qualification, is acceptable, provided some knowledge of radio has been obtained. Training is largely individual, the students working in pairs or groups of three when in the laboratories.

In an industrial college such as this, contact with research and development laboratories is direct. The College staff have attachments to the laboratories and the Company's engineers visit the College to lecture on their specialised subjects.

The previous Marconi College building is now being converted as an extension to the existing hostel, where each student has a private study-bedroom.

Marconi College is easily the oldest foundation of its type in the world, having been inaugurated by Marconi himself fifty-three years ago. The present Principal is Mr. R. E. Burnett, M.A. (Oxon), A.M.I.E.E., A.Inst.P., and the Director of Studies is Mr. R. G. Hulse, B.Sc.

The London-Sydney Cable Circuit

By A. H. Harris*, A.M.I.E.E.

In order to provide improved communication facilities between Australia and the United Kingdom a direct cable telegraph circuit between Sydney and London—a total of 15 000 *miles—has recently been established. This is the longest submarine cable circuit or "chain" as it is usually referred to which has so far been operated and the following article describes briefly the technical problems involved.*

THE cable route which is shown on the map (Fig. 1) comprises 7 cable sections, 2 landline sections and 9 intermediate stations, a list of which is given in Table 1. The intermediate stations serve a dual purpose. In the first place they function as repeaters for amplifying and regenerating the signals and secondly they act as collecting or disposal points for local traffic. This local traffic may be fed into the chain when the terminals are clear and similarly through a suitable selective mechanism controlled by the sending terminal, traffic may be "dropped" at any selected intermediate station.

On any unloaded cable, the transmitted signals are subject to considerable attenuation and phase-shift, these factors depending upon the electrical characteristics of the cable and the frequency of the signals. At each repeater station, therefore, a suitable equalizing network is required to reshape the signals; the longer the cable the greater is the difficulty experienced in obtaining optimum working conditions for the network and the relay-amplifier unit which works in conjunction with it.

After reshaping and amplification the signals are passed to the regenerator mechanism from which a substantially perfect replica of the original signal is retransmitted into the next cable in the chain. The regenerator is a synchronous electro-mechanical system in which provision is made for midway selection of the incoming signalling period, thus ensuring that each selection point occurs at a moment when failure is least likely to occur. The permissible range or margin for distortion on an average circuit is 50 per cent of the full signalling period (Fig. 2).

The signalling code employed on the submarine cable circuit is the three condition "cable-code," using the standard Morse alphabet. In this code a dot is represented by a negative impulse, a dash by a positive impulse and a space by no current, all signals being of equal length (Fig. 2).

Particulars of the lengths and types of submarine cable in use on the various sections of the Sydney-London circuit are given in Table 2. It is interesting to note in passing that the 3 466 mile submarine cable between Bamfield and Fanning Island is the longest in the world.

On the section between Sydney-Suva there is a single-

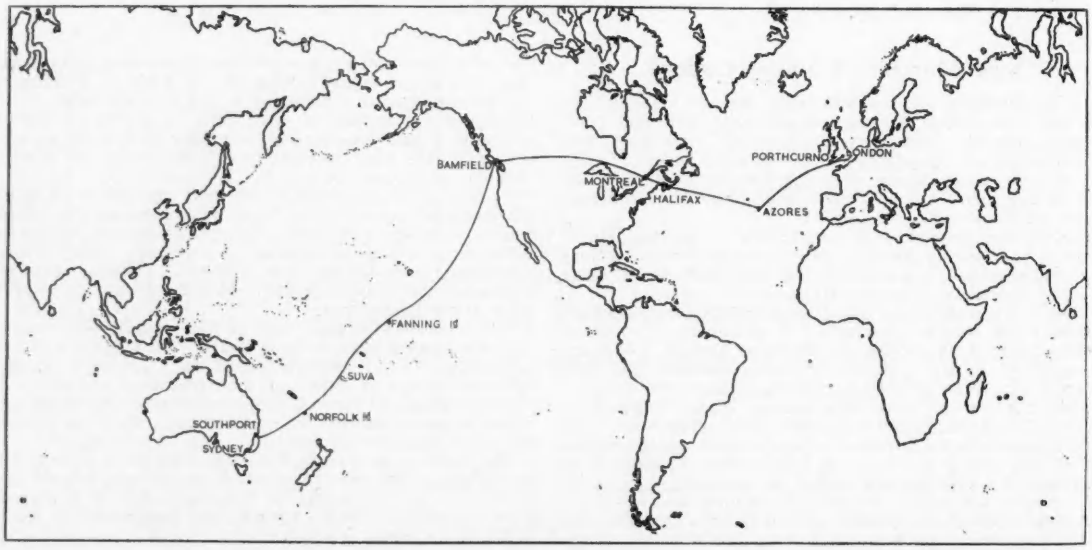
TABLE 1

Regenerator-repeater stations on 15 000 mile cable telegraph circuit

REPEATER STATIONS	CONTROLLING ORGANIZATION
Southport	Overseas Telecommunications Commission (Australia)
Norfolk Island ..	,, ,, ,, ,,
Suva (Fiji)	Cable and Wireless Ltd.
Fanning Island ..	,, ,, ,,
Bamfield	Canadian Overseas Telecommunication Corporation
Montreal	,, ,, ,, ,,
Halifax (Nova Scotia)	,, ,, ,, ,,
Azores	Cable and Wireless Ltd.
Porthcurno (Cornwall)	,, ,, ,,

*Cable and Wireless Ltd.

Fig. 1. The cable route



channel duplex telegraph circuit with relaying and regenerator points at Southport and Norfolk Island. This circuit is linked at Suva with one channel of a 3-channel time-division multiplex system extending from Suva to Bamfield with a relay station at Fanning Island. The Suva-Fanning Island and Fanning Island-Bamfield submarine cables are continuously loaded and the signalling speeds are therefore

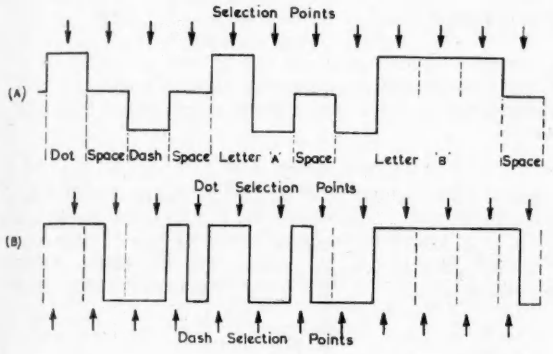


Fig. 2. Forms of code

(A) *Normal cable code.* (B) *Double-current cable code (same signals as in* (A)).

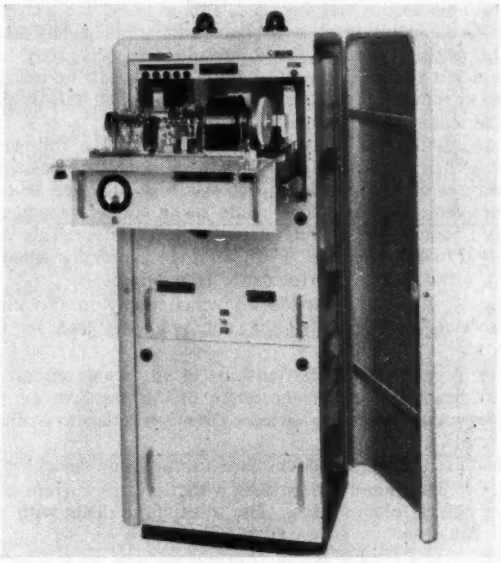
TABLE 2

CABLE SECTION	CABLE MILEAGE (NAUTICAL)	TYPE OF CABLE
Sydney—Southport	504	Unloaded submarine cable
Southport—Norfolk Island	846	,, ,, ,,
Norfolk Island—Suva	980	,, ,, ,,
Suva—Fanning Island	2 053	Continuously loaded submarine cable.
Fanning Island—Bamfield	3 466	,, ,, ,,
Bamfield—Montreal	2 710	Landline (Voice Frequency Telegraph circuit)
Montreal—Halifax	2 660	,, ,, ,,
Halifax—Azores	1 903	Unloaded submarine cable
Azores—Porthcurno	1 378	,, ,, ,,
Porthcurno—London	278	Landline (Voice Frequency Telegraph circuit)

considerably higher than those of the other submarine cables in the chain which are unloaded. The loaded cables can only be operated on a simplex basis and in order to cater for the peak traffic loads in either direction arrangements are made to work them in the direction Australia to the United Kingdom during the Australian day and in the opposite direction during the United Kingdom day.

At Bamfield the Sydney channel is relayed on to the landline circuit across Canada to Halifax, Nova Scotia. A multi-channel voice frequency telegraph system operates on the landlines one channel of which is keyed by the incoming signals from the submarine cable circuit. In order to do this the 3-condition cable-code signals are converted to a 2-condition code known as double current cable-code (Fig. 2), in which a Morse dot is represented by 2 elements "Mark," a Morse dash by 2 elements "space" and a letter-space by one "mark" element followed by a "space" element. The conversion from one code to the other is effected by suitable mechanism incorporated in the regenerator equipment at the relay station.

At Halifax the signals are translated back to 3-condition cable-code and passed on to the unloaded Halifax-Azores Porthcurno submarine cable circuit. Further conversion takes place at Porthcurno, the United Kingdom relay station, to fit in with the voice frequency telegraph system in operation on the Post Office landline circuit to London. In this connexion it may be mentioned that a frequency shift keying system for 3-condition code has recently been developed, overcoming one of the disadvantages of double-current cable code, that is, the high baud speed (double that of cable-code) required for a given rate of transmission of intelligence. In this latest



Cable & Wireless time division multiplex equipment.

system the mid-band frequency corresponds to the cable-code spacing periods and a shift of 50c/s up or down represents the dots and dashes respectively.

Sydney signals are received finally at the Central Telegraph Office in London, a direct printer being used for reception. This instrument prints the messages on a running tape which is gummed to a message form for delivery.

The planning of this circuit has involved the collaboration with Cable and Wireless Limited of four other Commonwealth telegraph undertakings, namely, the Overseas Telecommunications Commission (Australia), the New Zealand Department of Post and Telegraphs, the Canadian Overseas Telecommunication Corporation and the United Kingdom Post Office. It is a tribute to the smooth working of the Commonwealth organization that the circuit was brought into operation without encountering any serious technical or operational difficulties.

Acknowledgments

The writer is indebted to Cable and Wireless Ltd. for permission to publish this article.

Class-C Amplifier and Oscillator Design

(A Simplified Method)

By L. T. Apps*, A.M.I.E.E.

A simplified method of r.f. power amplifier and oscillator design is presented. This is based on Terman's method of approximate analysis, but short cuts are used in the form of charts or nomograms.

SEVERAL well-known methods of class-C analysis are available to the designer[1,2,3,4], and of these the Terman and Roake procedure[4] is probably the most widely used at the present time. Accurate results are yielded by this system but the sequence of analytical steps can be tedious when an optimum design is required or when the user is not familiar with the method.

To simplify the procedure in such cases the following method has been prepared. It will be seen that basically it consists of two charts, Fig. 2 and Fig. 3, which enable a complete analysis to be made using the valve characteristic curves and direct current values only. This can result in a considerable saving of time especially when a quick estimation of performance is required.

Fig. 1 shows the waveforms which apply in this class of service and indicates the abbreviations used in the text.

Fig. 2 enables the relationships of the anode circuit to be studied when either the angle of current flow or the anode voltage swing is varied. This is similar to a chart by Scott[5].

Details of the grid circuit are found from the chart in Fig. 3. The main curves deal with the grid current and drive power relationships. The inset curve deals with the bias equation.

Fig. 4 is a typical set of constant current valve characteristic curves which are used in the following example of this method of analysis.

The curves apply to a 3J/160E forced air cooled triode. Maximum ratings for class-C telegraphy operation are as follows:—

Maximum direct anode voltage	3kV
Maximum direct anode current	2·2A
Maximum direct anode dissipation	1kW
Maximum usable emission	10A
Maximum direct grid dissipation	75W
Maximum frequency for above ratings	120Mc/s

The valve amplification factor is 19.

Consider the case where it is desired to obtain the maximum power output at an anode voltage of 2·5kV using a flow angle of 140°.

From the characteristic curves, Fig. 4, point A is indicated as giving a good anode voltage excursion without undue grid current. The ordinates of this point are $V_{a(min)}$ 400V and $V_{g1(max)}+350$V. Current values at this point are $I_{a(pk)}$ 3·6A and $I_{g(pk)}$ 1·4A. Making a maximum emission current of 5A, which is well under the maximum rating value of 10A. Using Fig. 1 the two known values are the angle of flow required and the anode voltage swing, 140° and 84 per cent. Connecting these points and using the other three scales as indicated it is found that the anode efficiency will be 73 per cent, and the direct anode current 0·225 of the peak value while the anode load ratio is 1·73.

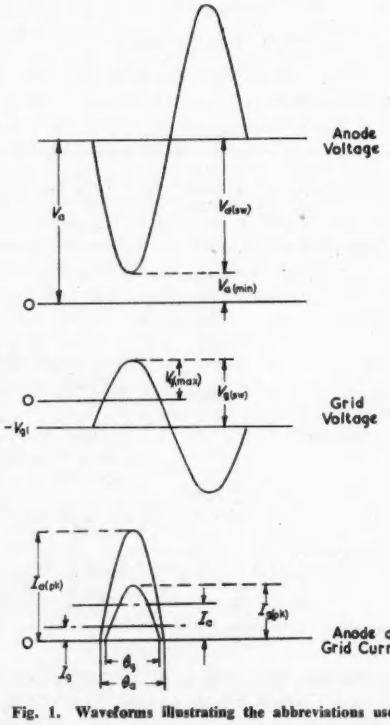


Fig. 1. Waveforms illustrating the abbreviations used

The following relationships may now be worked out:—

Direct anode current, I_a	= 810mA (3·6 × 0·225)
Power input	= 2025W (2500 × 0·810)
Power output	= 1480W (2025 × 0·73)
Anode dissipation	= 545W (2025 − 1480)

The figure of power output found is a calculated value only and in service circuit transfer losses, etc., must be subtracted from this value when arriving at the true output.

The anode load impedance is found by applying the ratio found from the chart to the anode voltage excursion and the direct anode current.

Anode load impedance = 1 500 ohms (2 100 ÷ (810 × 1·73))

* *Standard Telephones & Cables Ltd.*

The grid bias voltage must now be calculated. The standard formula is used for this purpose.

$$-V_{g1} = \frac{V_a}{\mu} + \left(V_{g(max)} + \frac{V_{a(min)}}{\mu}\right) \frac{\cos\theta_a/2}{1-\cos\theta_a/2}$$

The value of the last term may be found from the inset curve on Fig. 3. In this case ($\theta_a = 140°$)=0·52.

$-V_{g1} = 2\,500/19 + (350 + 400/19)\,0{\cdot}52 = -326V$

The peak r.f. grid voltage $V_{g(sw)}$ is, therefore, 326+350 =676V. The ratio of the bias to r.f. grid voltage is now required. In this case this figure is 0·48.

Referring to Fig. 3 the horizontal scale is entered at 0·48 and the left-hand scale readings obtained as shown. The grid circuit angle of flow is about 122° which deter-

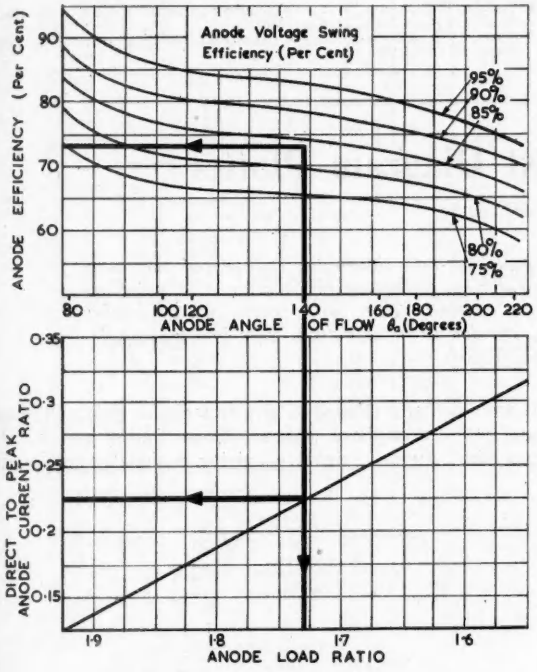


Fig. 2. Anode circuit relationships

mines the direct grid current ratio of 0·175 and the grid drive power ratio of 1·85. Using these figures the grid circuit relationships may now be obtained.

Direct grid current, I_g	=	245mA (1·4 × 0·175)
Bias source loss	=	80W (326 × 0·245)
Total grid drive power	=	148W (80 × 1·85)
Grid dissipation	=	68W (148 − 80)
Bias resistor	=	1330Ω (386 ÷ 0·245)

When the analysis is complete, allowance must be made for the grid drive power if the case considered is a self excited oscillator. In such an application the total grid drive power must be deducted from the calculated output power.

It will be seen that the above analysis applies to a reasonable state of affairs as no maximum ratings are approached and a reasonable efficiency has been obtained.

To show the relative accuracy of this simplified analysis the same basic parameters were used for a design using the original Terman method. The values obtained are tabulated on the following page.

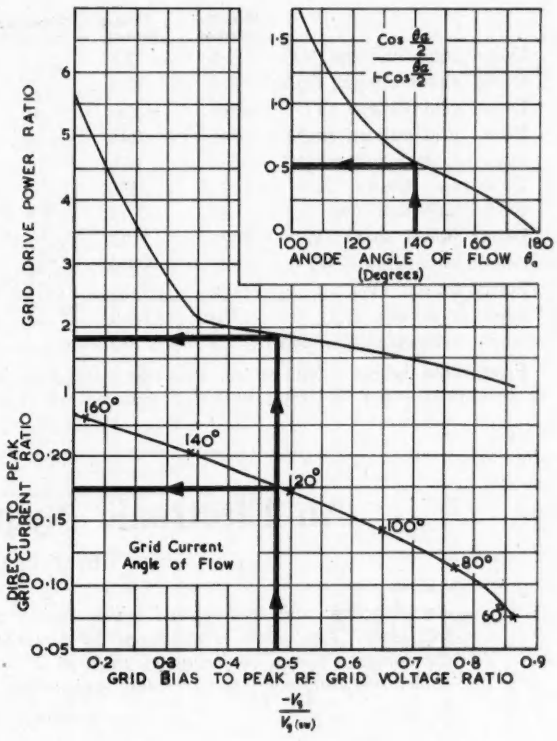
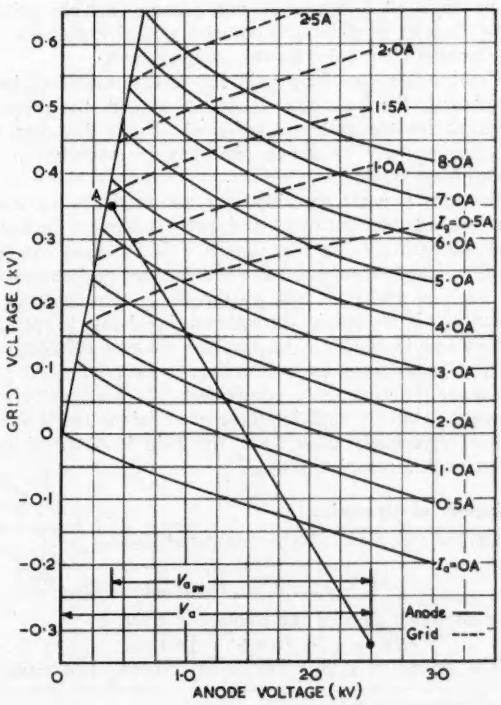


Fig. 3. Grid circuit relationship and cos θ values

Fig. 4. Characteristic curves for valve type 3J/160E



	Simplified Method	Terman Method	Difference (per cent)
Direct anode voltage (V)	2·5	2·5	–
Direct anode current (mA)	810	870	<7
Direct grid voltage (V)	−326	−326	0
Direct grid current (mA)	245	245	0
Peak r.f. grid voltage (V)	676	676	0
Grid bias resistor (Ω)	1330	1330	0
Grid dissipation (W)	68	70	<3
Direct power input (W)	2025	2170	<7
Anode dissipation (W)	545	610	<10
Power output (W)	1480	1560	5
Load impedance (Ω)	1500	1420	6
Anode efficiency (per cent)	73	72	<1·4

From these figures it will be seen that this method gives an overall accuracy of result within 5 per cent of that obtained by the original method on which it is based.

It will be seen that this method enables an analysis to be made rapidly and without reference to harmonic analysis or similar methods. If required, a closer check of the conditions obtained may be made using the methods based on Ref. 1 or 3.

Acknowledgment

The author wishes to thank Standard Telephones and Cables Ltd for permission to publish this article.

REFERENCES

1. PRINCE, D. C. Vacuum Tubes as Power Oscillators. *Proc. Inst. Radio Engrs. 11*, 275, 405 and 527 (1923).
2. Federal Telephone ; Radio Corpn. F.T.R. Handbook of Tube Operation. Ed. 3, p. 25.
3. CHAFFE, E. L. A Simplified Harmonic Analysis. *Rev. Sci. Instrum. 7*, 384 (1936) and *8*, 227 (1937).
4. TERMAN, F. E., ROAKE, W. C. Calculation and Design of Class C Amplifiers. *Proc. Inst. Radio Engrs. 24*, 620 (1936).
5. SCOTT, H. J. A Note on Class C Power Amplifier Design. *Proc. Inst. Radio Engrs. 40*, 1250 (1952).

An Electronic Nyquist Diagram Plotter

By J. L. Douce*, M.Sc.

An electronic unit is described which derives the ratio of two sinusoidal voltages of the same frequency. The result is displayed on a conventional c.r.t. giving the information as a point on the complex plane. A frequency ratio of 20 to 1 is covered using two ranges: by a suitable choice of components the operating region may be extended to include from very low frequencies ~ 1c/s to about 10kc/s.

IN the design and construction of feedback systems, such as servomechanisms or high-quality audio amplifiers, it is essential to obtain the response of the system to a sinusoidal input. For a linear system, the output is sinusoidal, of the same frequency as the input, but differing from the input in amplitude and phase. Thus the gain of the system is, in general, a complex quantity, and may be represented by a point on the complex plane.

Plotting the open-loop gain for several values of input frequency, the resultant locus is termed the Nyquist diagram for the system considered. From this diagram, conclusions may be drawn regarding the stability of the closed-loop system[1].

Previous systems described for automatically recording the Nyquist diagram rely on electro-mechanical devices to find the ratio of the two signals. This method can give results of high accuracy, but often the cost and complexity of such a device is not worthwhile. The unit to be described is electronic throughout, involving 16 pentode valves and 15 diodes. The ratio of the two voltages considered is obtained as two voltages, representing the in-phase and out-of-phase components of the gain of the element. Thus by applying these potentials to the X and Y plates respectively of a C.R.T. the gain is obtained as a point on the complex plane.

Principle of Operation

Let the two signals to be compared be:

$$e_1 = e_i \sin \omega t$$
$$e_2 = e_o \sin (\omega t + \phi).$$

The unknown gain of the element is given by:

$$e_2/e_1 = e_o/e_i \, [\cos \phi + j \sin \phi] \quad \ldots\ldots\ldots\ldots (1)$$

The operation of the unit is as follows. The signal e_1 is amplified and clipped to give rectangular pulses in-phase and 90° out-of-phase with e_1. These pulses are used to gate the "output" signal e_2, giving a signal whose mean

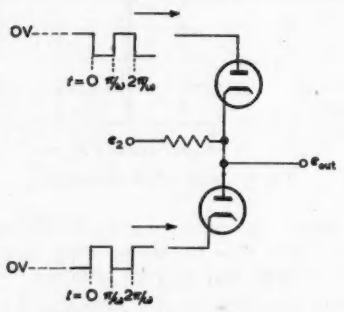


Fig. 1. The basic gating element

voltage is proportional to the in-phase and out-of-phase components of e_2.

The basic element is shown in Fig. 1. The diodes are non-conducting for the first half-period, and clamp the output at 0V for the remainder of the period.

Hence the output is given by:

$$e_{out} = e_2 = e_o \sin (\omega t + \phi) \quad 0 < t < \pi/\omega$$
$$= 0 \quad \pi/\omega < t < 2\pi/\omega.$$

The mean value of the output is:

$$e_{mean} = \omega/2\pi \int_0^{\pi/\omega} e_o \sin (\omega t + \phi) \, dt$$
$$= 1/\pi \, e_o \cos \phi$$

* *Manchester University.*

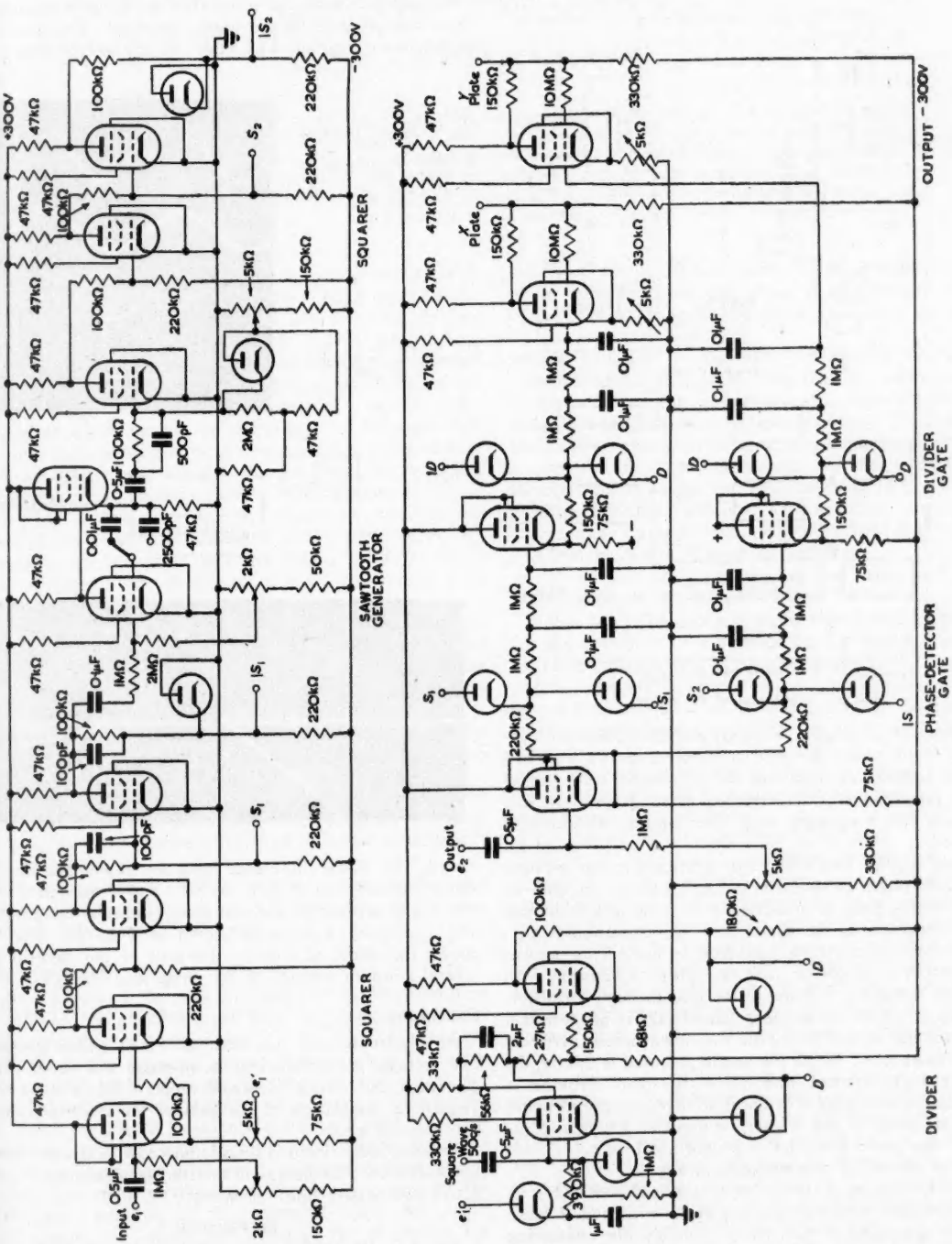


Fig. 4. The circuit of the plotter

Thus the mean output voltage is proportional to the component of the signal e_2 which is in phase with e_1.

To derive a square wave, 90° out-of-phase with the waveform e_1, the initial square wave is passed through a Miller

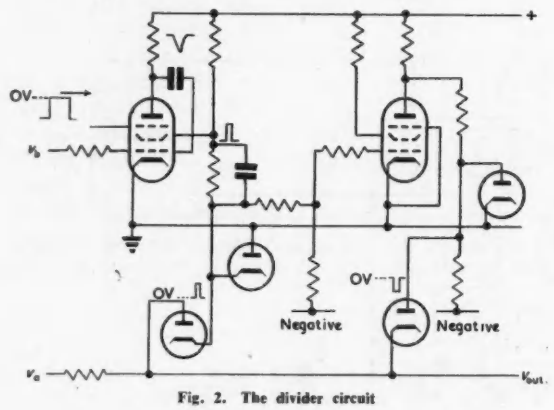


Fig. 2. The divider circuit

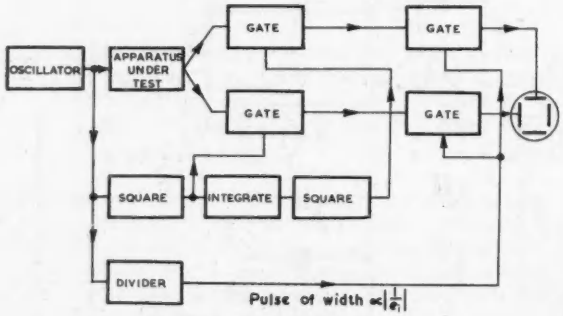


Fig. 3. Arrangement of the plotter

integrator[2]. This gives a sawtooth waveform, and the output waveform passes through its mean value at a time $\tau/4$ after the square wave transient occurs, where τ is the period of the input waveform. Thus by passing the sawtooth waveform into a squaring stage, the required waveform is produced.

Having derived two voltages proportional to the in-phase and out-of-phase components of the signal e_2, the gain of the element is given as proportional to these signals divided by the modulus of the signal e_1. This operation is performed using an electronic analogue divider[3]. This element is essentially a suppressor switched Miller integrator, with the input voltage v_b applied to the grid through a resistor. The rate at which the anode potential falls is proportional to the voltage v_b, and hence the run-down time is inversely proportional to v_b. While the anode potential is falling, the screen current is small, and hence the screen provides a large positive-going pulse of duration inversely proportional to v_b. This pulse is used to gate the input v_a, giving a waveform whose mean potential is proportional to v_a/v_b. This process is illustrated schematically in Fig. 2.

A block diagram of the complete unit is shown in Fig. 3.

The complete circuit of the unit is shown in Fig. 4 (page 33). The equipment is built on two chassis, one containing the gating waveform generator and the other the switching units. Type EF50 valves are used throughout, but the unit would be rendered more compact by using double triodes for cathode-follower and amplifier stages.

The observed waveforms, for a typical input, are shown in Fig. 5.

Experimental Results

The response of the unit is tested using a variable-frequency phase measuring device previously described[4]. This is shown in the block diagram Fig. 6(a). As the potentiometer is

Fig. 5 (right). Observed waveforms

(a) *input* e_1 (b) *input* e_2 (c) *in phase component of* e_2 (d) *out of phase component of* e_2.

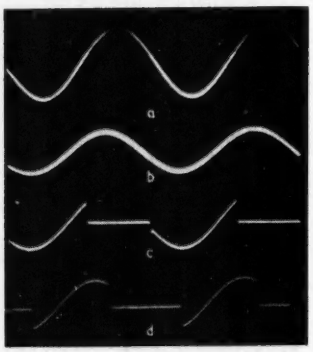
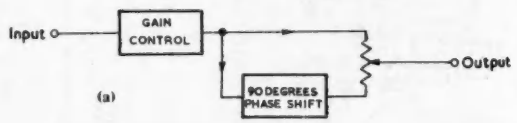
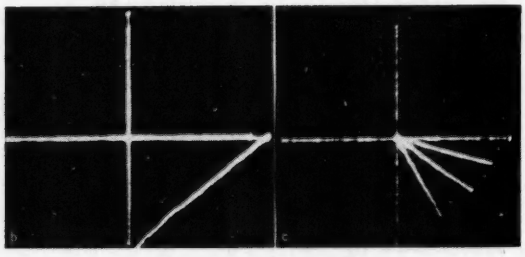


Fig. 6 (below). (a) Test apparatus (b, c) response of the unit





varied, the phase difference between input and output varies continuously from 0° to 90°, and it may be shown that the gain locus on the complex plane is a straight line. The experimental locus is shown in Fig. 6(b). Fig. 6(c) shows the effect of varying the gain of the element for several constant settings of the phase-shift control.

Conclusion

An electronic unit has been described which provides two voltages proportional to the in-phase and out-of-phase gain of a unit, for a sinusoidal input. This gives a convenient representation of the gain of the element using a conventional c.r.t.

Frequent adjustment is found unnecessary, and the unit is invaluable for demonstrating the transfer functions of both active and passive linear networks.

REFERENCES

1. West, J. C. The Nyquist Criterion of Stability. *Electronic Engng. 22*, 169 (1950).
2. Briggs, B. H. The Miller Integrator. *Electronic Engng. 20*, 243 (1948).
3. Douce, J. L. A Simple Analogue Divider. *Electronic Engng. 26*, 155 (1954).
4. West, J. C., Potts, J. A Simple, Variable Frequency, Phase-measuring Device *Electronic Engng. 24*, 402 (1952).

An Alternating-Voltage Stabilizer

with Form-Factor Correction

By D. J. R. Martin*, B.Sc., A.Inst.P.

A description is given of a unit which provides a constant-voltage supply for variable loads up to 150W. The output voltage is 240V and varies by less than ±0·2 per cent for changes in line voltage of ±12½ per cent, frequency changes of ±4 per cent and load changes between 50W and full load. Sinusoidal input waveforms suffer negligible distortion; with distorted input waveforms the form-factor is automatically corrected by simultaneous stabilization of the rectified-mean and r.m.s. values of the output voltage.

THE stabilizer to be described was designed to satisfy the general need for an a.c. supply which would maintain a constant voltage to within a fraction of 1 per cent in spite of wide changes in mains voltage, applied load and frequency. Rapid response was considered essential, and a further stipulation was that the waveform of the mains supply, if originally sinusoidal, should suffer negligible distortion by the stabilizer. At the same time the unit was required to be of only moderate size and cost. These requirements have been met, and the stabilizer incorporates an additional facility which corrects the form-factor of a distorted input waveform by simultaneous stabilization of the rectified-mean and r.m.s. voltages; this unique course is simpler than providing a waveform that is truly sinusoidal regardless of input waveform, and for most purposes is as useful.

The controller circuit uses a novel extension of the "series impedance" principle, in which a pair of valves is operated in push-pull without any standing direct voltages. In the present case, the preceding amplifier stage is also entirely a.c.-operated, and direct coupling is used to the controller valves themselves; control is obtained by variation in the negative feedback applied over the two stages. The deviation-detector circuit uses a neon stabilizer and a Thermistor as reference elements for stabilization of the rectified-mean and r.m.s. voltages respectively; correction of the latter quantity is effected by the injection of suitable harmonics into the output.

The complete unit has been built on a chassis measuring 16in by 9in; no attempt at miniaturization or extreme economy of space has been made.

The Controller

Fig. 1 shows the circuit diagram of the complete stabilizer. The unstable mains input is first boosted by the auto-connexion of transformer T_1 to a value which is about 20V above the required output voltage when the input voltage is at its lower limit. The variable excess over the required value is dropped across the primary of transformer T_2, which reflects the impedance of valves V_1 and V_2. These valves are operated with an alternating control signal on the grids. The screen-grids are also operated from an a.c. supply, but small rectifiers are interposed to prevent the screen-grids emitting on their negative half-cycles. The control-grids are resistance-coupled to the anodes of the preceding valve, a double triode; this valve is also operated without any standing direct voltages. An arbitrary signal from the input transformer is injected into the cathode circuit of this stage, and control of the output impedance of the complete controller circuit is obtained by variation of the degree of negative feedback applied to the grids of V_3 via resistors R_{11} and R_{12}.

This variation in feedback is effected through the Metrosil† disks M_1 and M_2. Metrosil is a semi-conductor having a non-linear voltage-current characteristic. For small values of alternating voltage it may be regarded as having a variable a.c. resistance whose magnitude is a function of the direct current flowing through the substance. In this application, the two Metrosil disks form part of the negative feedback network, and a direct current flows differentially through them, controlling their a.c. resistance and thus the degree of negative feedback.

Stabilization of the Rectified-Mean Voltage

From this point, it is a straightforward matter to arrange for the provision of a suitable control signal. A portion of the stabilizer output is rectified and smoothed and compared with a stable direct reference voltage; the difference is amplified and used as the control signal. In Fig. 1, V_8 is the sample-voltage rectifier; the smoothing circuit is formed by R_{20}, R_{21}, C_9 and C_{10}; V_7, an 85A1 neon stabilizer, provides the stable reference voltage, which also feeds the screen-grid of the voltage amplifier V_6. V_5 is a cathode-follower, necessary to supply the current (up to about 50mA) taken by the Metrosil disks.

The h.t. supply for V_5 and V_6 is derived from the unstabilized mains input and accordingly is subject to the same fluctuations. This arrangement, in conjunction with the stabilized feed for the screen grid of V_6, causes the fluctuations to be passed on directly, through V_5, to the Metrosil disks, and the chosen circuit values are such that a considerable measure of self-stabilization results; this reduces the required control signal from the deviation detector and a more stable output voltage is thereby achieved.

The direct current in the choke L_1 causes a voltage drop on account of the inherent d.c. resistance of the latter. To prevent this voltage from biasing the grids of V_2 positive, a third Metrosil disk M_3 is introduced, in series with the resistor R_{15}, whose resistance is chosen to be approximately equal to that of each half of L_1; by returning the centre-tap of transformer winding A-C-B to the junction of these two components, instead of to earth, compensation is obtained. An alternative measure would be to employ a double-wound transformer in place of choke L_1.

The fact that the neon stabilizer is fed from an unstable

* *British Scientific Instrument Research Association.*

† *Marketed by Metropolitan-Vickers Electrical Co., Ltd.*

supply precludes realization of the maximum stability obtainable from this valve. However, a considerable measure of compensation for its incremental resistance is obtained through the positive feedback introduced by the common cathode resistor R_{16}, whose optimum value was found experimentally. If the utmost stability is required a separate reference neon tube may be used, supplied from the output of the stabilizer, and the first tube retained for the screen supply of V_6.

porates a supplementary deviation-detector which is sensitive to the r.m.s. value of the output voltage. Any departure of the r.m.s. voltage from the pre-set value results in a 100c/s (nominal) signal being applied to the grid of V_6, and subsequent intermodulation with the fundamental frequency causes odd harmonics to appear in the output in such a phase as to correct for the discrepancy in the r.m.s. voltage. This facility in no way interferes with the operation of the principal deviation-detector, which maintains the

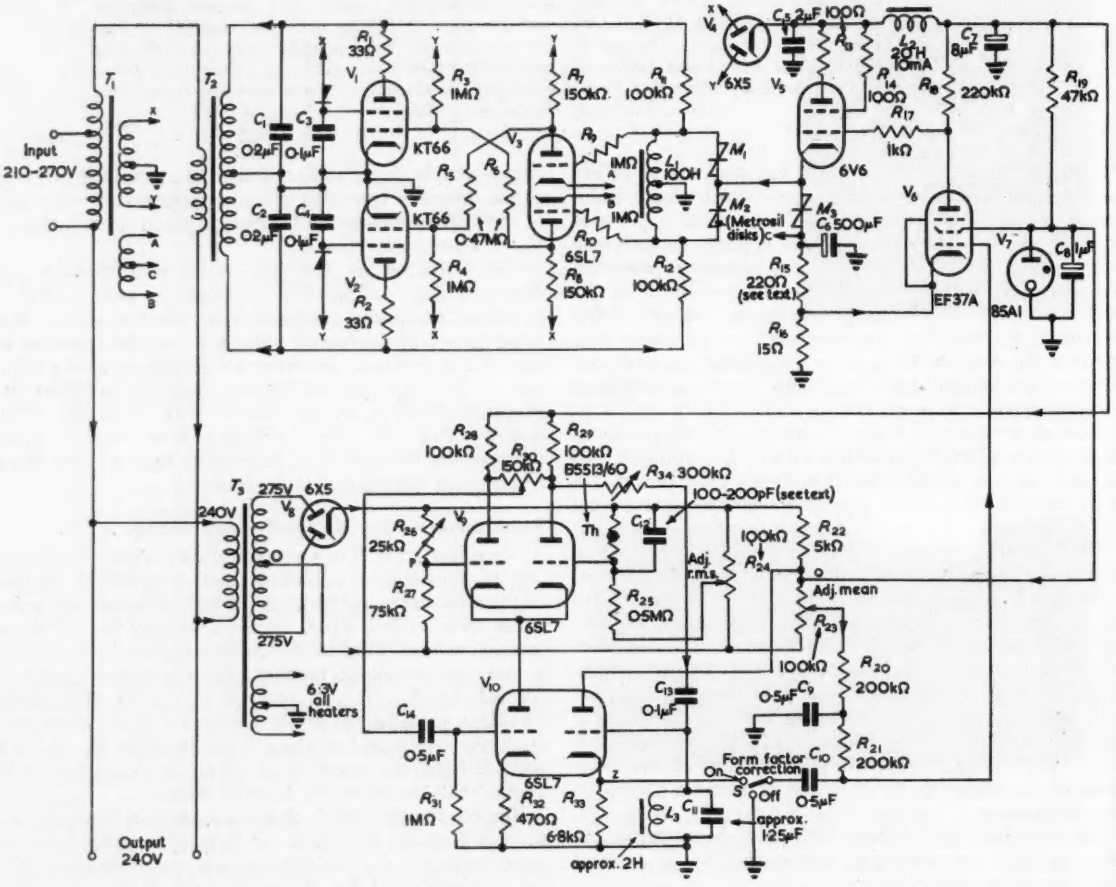


Fig. 1. The voltage stabilizer

$T_1 = 75W$. *Pri*: 240*V*. *Secs*: 300*V* (*auto*); 325-0-325*V*(X-Y); 7-0-7*V*(A-C-B).
$T_2 = 50W$. *Pri*: 100*V*. *Sec*: 800-0-800*V*.
$T_3 = 30W$. *Pri*: 240*V*. *Secs*: 275-0-275*V*; 6·3*V*, 5*A*.
$L_1 = 100H$, *centre-tapped; zero polarizing d.c.; "Mumetal" core.*
$L_2 = 20H$, *10mA*.
$L_3 = approx.\ 2H$.
$M_1, M_2, M_3 = Metrosil\ disks;\ 1in\ diam.\ annular\ 1/16in\ thick;$ M_1 *and* M_3 *should be matched.*
Th = Thermistor type B5513/60 (S.T.C.) heater not used.

Form-Factor Control

Some waveform distortion might be expected on account of the non-linearity of the Metrosil characteristic, but in practice the alternating current in each disk is a small fraction of the direct current, and the distortion is negligible. It is assumed, however, that the d.c. supply is well smoothed, for any ripple distorts the output waveform by the introduction of odd harmonics. This property of the circuit is turned to useful account, for by introducing a controlled amount of second-harmonic ripple on to the direct current, the form-factor of the mains supply may be corrected or modified as required. The circuit shown in Fig. 1 incorrectified-mean voltage at its own, and possibly different, pre-determined value.

The r.m.s.-sensitive detector is a Thermistor bridge, supplied with a full-wave rectified a.c. derived from the stabilizer output. Rectification leaves the r.m.s. value unaltered, while introducing a predominant second-harmonic component and suppressing the fundamental. The output from the bridge is amplified by V_9 and filtered to provide the necessary 100c/s control signal. The Thermistor bridge needs temperature compensation, though this has not been shown in the diagram; it may conveniently be provided by a type KB2322/80 Thermistor, suitably shunted, inserted

in series with R_{26}. Thermistors vary widely in their characteristics, and the correct value of shunt in each individual case has to be found by experiment.

When the circuit is initially put into operation, R_{25} is adjusted for a null balance between points P and Q. R_{30} is adjusted for maximum discrimination against in-phase components, that is, for minimum signal at point Z when the grids of V_9 are strapped together. R_{34} should be set for the minimum value consistent with adequate filtering of the signal at Z (this adjustment is a compromise between maximum r.m.s. stability and permissible distortion on a sine-wave input). Capacitor C_{12} phases out the quadrature component inevitable from a Thermistor bridge, and its correct value is quickly found by experiment. The mean and r.m.s. values of the stabilized output are independently pre-set by R_{23} and R_{24} respectively. Switch S cuts out the form-factor correction and is useful during initial adjustments.

Performance

The output voltage of the stabilizer is constant to within ±0·2 per cent against changes in mains voltage of ±12½ per cent (i.e. the stabilization ratio is 63:1) and frequency changes of ±4 per cent for any load from 40W to 150W. If the input waveform remains unaltered the response time to voltage and load changes is of the order of 1 cycle. A change in the r.m.s. value of the input voltage in the absence of any corresponding change in the rectified-mean value needs a longer time (about one second) for complete correction, due to the lag introduced by the Thermistor.

If a fixed load may be guaranteed, the power output may be increased to 600W by shunting the controller transformer with a suitable resistor and increasing the rating of T_1. The power output may also be increased by restricting the permissible input voltage range; for example, if the total input-voltage excursion does not exceed 10 per cent between limits, the stabilizer may be modified to work over the continuous load range 40 to 400W.

Over a period of continuous running for one month, the output voltage has never gone outside the 0·2 per cent limits for all normal changes in input voltage, frequency and ambient temperature.

Acknowledgments

The author wishes to thank the Council and Director of the British Scientific Instrument Research Association for permission to publish this article, and Dr. A. J. Maddock, in whose department the research was carried out, for advice on its preparation.

Electronic Machine Tool Control

The Applications Laboratory of Ferranti Ltd. has recently developed a computor capable of controlling a machine tool, as for example a milling machine.

The whole system comprises:

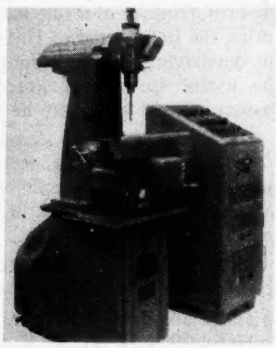
(1) A tape perforator by which the planning engineer instructs the computor to perform the operation required. This involves coding the dimensions of the article, together with machining instructions as perforations on a strip of paper tape.

(2) A tape reader which transfers the instructions coded on this tape to the computor.

(3) The computor itself which takes this basic information and calculates precisely the movements which the table of the machine tool will have to make to cut the required shape.

(4) A magnetic tape recorder which records the instructions for these movements.

(5) The machine tool itself complete with tape-controlled servo-mechanisms and measuring devices which move under the control of the tape playback unit.



The method of measurement employed is based on the use of Merton diffraction gratings[1]. The accuracy of the whole system is limited by the accuracy of the machine tool itself.

Illustrated is a simpler application in the form of a small drilling machine. This has a table which can be positioned to within two ten-thousandths of an inch merely by setting up the required dimension on a group of dials. In this case the instructions are so simple that no calculations as such are required, and there is no necessity for a computor. Only a simple addition to this machine is needed to enable it to read the position of a group of holes directly from punched paper tape if it is required to repeat a sequence of holes in an item such as a gear plate.

1. Diffraction Gratings in Industry. *Electronic Engng. 26*, 213 (1954).

New Australian Army Midget Radio

A portable radio station that will operate efficiently even after being submerged in water or mud has been developed in Australia.

Called the A510 Portable Wireless Station, it is made by Amalgamated Wireless (Australia) Ltd., at their factory at Ashfield, Sydney.

The unit was designed for the Australian Army which wanted a light, portable radio transmitter and receiver with a range of at least 4 000 yards for battalion communication.

It had to be rugged, simple to operate and so designed that it would fit into ordinary army webbing equipment.

The A510 weighs 37lb (half that of current portable radios used by the Australian Army); it can be carried easily by one man in an infantryman's basic pouches attached to his belt; and simple on-off switches are the only controls. It can be used for telegraphy or telephony.

The frequency band, 2 to 10Mc/s, enables communication to be established quickly and clearly, day or night and in any weather, and the general performance is claimed to be superior to that of previous portable radios used by the armed services.

Although as a portable set it has a range of about five miles, a fixed wire aerial increases the range to 500 miles under good conditions.

British forces in Malaya have tested the equipment exhaustively under actual fighting conditions with outstanding success.

It is understood that the British Army has placed an order worth £A250 000 for these equipments.

It is of interest to compare the A510 with the huge mass of equipment which was necessary for radio communication in the 1914-18 war. Sometimes this was carried in special packs by five or six horses. Another method was to mount it on two four-horse limbers. A later refinement was a mobile transmitter and receiver mounted on a motor tricycle.

Notes from North America

A New Beam Switching Tube

A NEW type of beam switching tube is being developed by the Burroughs Research Centre, Paoli, Philadelphia, for use in computors.

The tube employs the beam forming properties of crossed electric and magnetic fields, the latter being provided by a small circular permanent magnet placed externally round the tube.

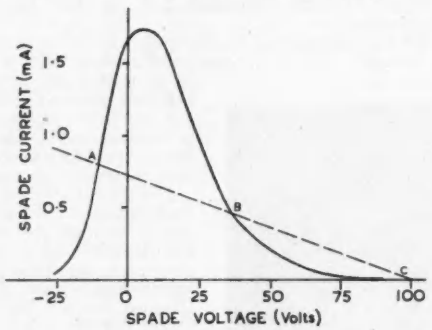
Internally, the tube is composed of ten groups of electrodes mounted radially about a central cathode. The basic elements of each group are:

1. A spade to form and lock the beam.
2. A grid to switch the beam.
3. A target to give a useful output.

By forming the beam on any one spade an output signal is produced on the corresponding target plate. Since the beam may be automatically formed and locked on any spade, there are ten discrete outputs associated with the tube.

An eleventh stable state occurs when all the elements of the tube are positive with respect to the cathode. This is the *clear* condition in which there is no output to any target plate.

By lowering the voltage of any one spade from the clear condition, the following characteristic curve is obtained.



Spade-current/spade voltage.

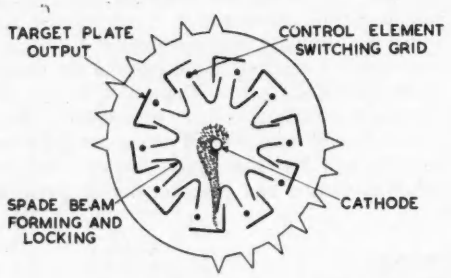
Of the three possible operating points, A, B, and C, only A and C are stable, while B is unstable.

When the tube is in the clear condition, all the spades are in state C. By lowering the voltage of any one spade beyond point B with a suitable series load, it will assume its other stable state, which is at near-cathode potential. This affects the relationship between the electric field and the magnetic field so that the beam forms to that spade in the manner shown.

Over 90 per cent of the beam is utilized in producing an output with a pentode type characteristic. The remainder is used automatically to form and lock the beam in position. This is obtained without suppression, and a wide variety of target resistor load lines can intersect the constant current portion of the curve with negligible crosstalk.

When a beam has been formed on a spade it can remain there indefinitely, or it can be advanced by lowering the associated grid voltage.

A voltage drop on the switching grid will disturb the electric field so that enough of the beam is deflected to the leading spade to cause that spade to assume its other stable state (A). The beam will now be formed on this spade.



Cross-section of beam switching tube showing beam forming.

Because of their shape and position, the grid electrodes give a very uniform switching action. This action is in the order of 0·1 microsecond, and draws negligible current.

Since the switching grid will affect the beam only in the region associated with the grid, the grid electrodes are connected in two groups, the odd numbered grids in one group and the even numbered in the other. In this way it is possible to use a d.c. input and still secure single position stepping which eliminates the necessity for a critical pulse width for this type of operation.

I.R.E. Awards

THE Institute of Radio Engineers has awarded Harald T. Friis, Director of Radio Research, Bell Telephone Laboratories, the IRE Medal of Honour. The award was made for his outstanding technical contributions in the expansion of the useful spectrum of radio frequencies, and for the inspiration and leadership he has given to young engineers.

The Morris Leibmann Memorial Prize was given to Arthur V. Loughren, Director of Research, Hazeltine Corporation, for his leadership and technical contributions in the formulation of the signal specification for compatible colour television.

Bernard Salzberg, Naval Research Laboratory, Washington, D.C., received the Harry Diamond Memorial Award.

The Vladimir K. Zworykin Television Prize Award goes to Harold B. Law, RCA Laboratories Division, Princetown, N.J., for his contributions to the development of the shadow-mask tri-colour television picture tube.

Seventy-six leading radio engineers and scientists were elected Fellows of the Institute by the Board of Directors at a meeting held in November. The grade of Fellow is the highest membership grade offered by the Institute and is bestowed only by invitation on those who have made outstanding contributions to radio engineering or allied fields.

Among the overseas recipients of the Fellow award are T. E. Goldup, a director of Mullard Ltd, and G. W. O. Howe, who until his retirement was Professor of Electrical Engineering of Glasgow University.

LETTERS TO THE EDITOR

(We do not hold ourselves responsible for the opinions of our correspondents)

Relay Scale-of-Two Circuits

DEAR SIR,—It was with interest that we read the article by Mr. R. C. M. Barnes. Recently we developed a scale-of-two circuit for use on low voltage, i.e. 2 to 6 volts for model control work. This circuit was designed to switch on then off a certain piece of equipment by remote control, and we think that other readers may find the circuit of use and interest.

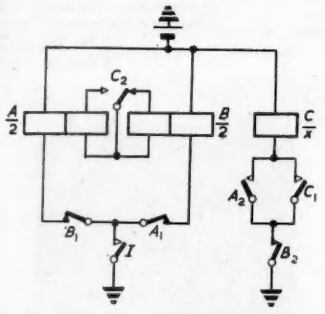


Fig. 1. Scale-of-two circuit for use on low voltage

The circuit is shown in Fig. 1. For normal work a coil resistance range of 50 to 200 ohms has been found satisfactory—50 ohms for 2 to 3 volt operation and 200 for 6 volts. The action of the circuit is, I contact makes and completes the operation circuit for both $A/2$ and $B/2$, however the fact that the one coil of $B/2$ is short-circuit makes that relay slow to operate. $A/2$ is therefore in a "fast to operate" condition and operates, contact A_1 must be the first to break, and do so before A_2 operates, so that the coil of $B/2$ is disconnected. A_2 makes the operating circuit for C/x and it operates with the contacts C_1 locking the relay.

Contact C_2 takes the short-circuit off $B/2$ coil and puts it across $A/2$ coil. Thus when the pulse is finished, $A/2$ has become slow to operate, $B/2$ fast to operate and C/x remains in an operated condition.

A further operation of the impulse contact (I) will cause $B/2$ to operate, with B_1 preventing the slowed $A/2$ relay, and B_2 contact releasing C/x.

Thus all contacts are, after the release of $B/2$, in a normal state.

While the circuit is quite useful for low voltage work it suffers from the trouble that at the end of an impulse the operated relay—either $A/2$ or $B/2$ is in a slow-to-release condition, this makes the maximum number of pulses per minute a matter of about 200. If, however, another contact was placed in series with each "slugging" coil so that the coil would not become short-circuit until the particular coil had released, then the circuit should be capable of about 600 impulses per minute.

Yours faithfully,

JAMES S. KENDALL.

Kendall and Mousley,
Birmingham.

The Author replies:

DEAR SIR,—I find Mr. Kendall's scale-of-two circuit interesting as it uses a principle of varying the relative operating speeds of two relays which I had not seen before. With a power supply of only 2 volts it is probably best to forget all those circuits in which relays operate on less than full line voltage. If we assume that the circuit is to be controlled over one wire (relay contact I), my Fig. 12(a) is a competitor, but it uses two rather specialized relays which might not be so readily available as the three relays in Mr. Kendall's circuit.

My Fig. 23(a) suggests another way of tackling this problem with three relays. The incoming signal could operate a relay I with two K contacts (as described in the last paragraph of my article). There is little to choose between this and Mr. Kendall's circuit. Personally I would prefer to use the adaptation of Fig. 23(a) if the circuit has to operate frequently, because it avoids the timing feature and can therefore tolerate a lower standard of mechanical maintenance.

Yours faithfully,

R. C. M. BARNES.

Electronics Division,

Atomic Energy
Research Establishment,
Harwell.

The Determination of the Dynamic Properties of Crystal Diodes

DEAR SIR,—There are three methods by which crystal diodes have been used in amplifiers to impart non-linear characteristics. The first method makes use of the property that the dynamic or a.c. resistance of a crystal varies with the quiescent or d.c. current passing through it, and hence the transmission loss of an attenuation pad, in which crystals are incorporated, may be varied by means of a d.c. control current[1,2]. The second application merely uses the diode as a voltage controlled switch to introduce either an attenuating resistance or feedback[3]. The third method combines both properties, the crystal shunting a high resistance so that when the diode is conducting the high resistance is by-passed by the low resistance of the crystal, and when the control voltage causes conduction to cease, the high resistance is introduced[4].

In all these methods the dynamic properties of the crystal are important, and although the dynamic resistance may be obtained from the static voltage current curves, certain unexplained occurrences in the characteristics of an amplifier, utilizing method three, caused a brief investigation of the dynamic properties.

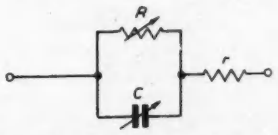


Fig. 1. Equivalent circuit of a crystal diode[5]. For low values of the bias current $R > r$ and this condition enables balance of the bridge circuit in Fig. 2 to be obtained

A Wien bridge circuit described in the literature[1] was first used, but as a meter for determining the quiescent current through the crystal was required, and also since the capacitance of the crystal (see Fig. 1) made the balance point difficult to determine, the variation of the Schering bridge shown in Fig. 2 was used and found satisfactory.

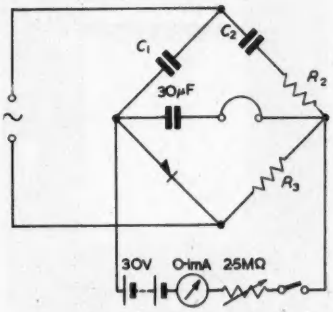


Fig. 2. Bridge circuit at balance

$$R = \frac{C_2}{C_1} R_3 \text{ and } C = \frac{R_2}{R_4} C_1$$

The dynamic resistance determined by this method was about half that determined from the static curves, and also it decreased both with frequency and with the a.c. voltage applied. It was also found that the capacitance was non-linear as expected. The results fully explained the behaviour of the amplifier.

The work described in this letter was carried out at the Admiralty Signal and Radar Establishment, and the writer is indebted to the Admiralty for permission to publish this letter.

Yours faithfully,

G. STUART-MONTEITH

Admiralty Signal, and Radar
Establishment.

REFERENCES

1. STANSEL, F. R., N1 Carrier—Selection of Varistors for use Compandors. *Bell Lab. Rec. 31*, 501 (December, 1953).
2. FRACASSI, R. D. The Compandor in N1 Carrier. *Bell Lab. Rec. 31*, 452 (November, 1953).
3. BAXTER, I. G. A Square Root-Law Circuit. *Electronic Engng. 26*, 97 (1954).
4. HOLBROOK, G. W. A Variable Gain Amplifier. *Electronics 25*, 200 (April, 1952).
5. TORREY and WHITMER. Crystal Rectifiers. *Radiation Laboratory Series No. 15* (McGraw-Hill, 1948).

ELECTRONIC EQUIPMENT

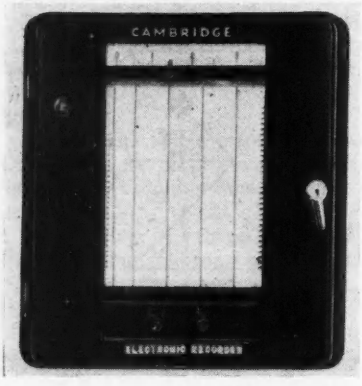
A description, compiled from information supplied by the manufacturers, of new components, accessories and test instruments.

Electronic Recorder

(Illustrated below)

THE Cambridge Electronic recorder is of the continously balancing type, the rebalancing of the measuring circuit being effected by means of a small servomotor. Any voltage error due to unbalance is converted into a 50c/s signal of appropriate phase and after electronic amplification, is applied to the servomotor to drive it in such a direction as will restore balance. Damping of the recorder movement is obtained by feeding, to a suitable point in the amplifier, the voltage from a tachometer generator coupled to the servomotor.

For most applications the instrument is supplied as a recording potentiometer



for the measurement of small d.c. potentials, but alternatively the measuring circuit can be arranged as a low resistance current measurer, as a d.c. bridge or, with certain limitations, as an a.c. bridge or potentiometer. Full scale sensitivities down to 1mV are possible.

The electronic recorder is available for single or multipoint recording. Single point recorders use a syphon type pen and provide a continuous line record. Multipoint records utilize a turret marker which picks up ink from reservoir pads and prints a circular dot on the chart. Either 2, 3, 4 or 6 circuits are selected in turn by the recorder mechanism and the records printed in distinct colours at the rate of 10 points per minute.

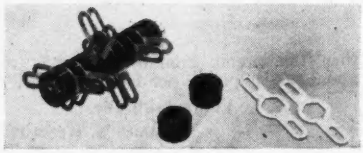
Cambridge Instrument Co Ltd,
13 Grosvenor Place,
London, S.W.1.

Tag Assemblies

(Illustrated above right)

THE McMurdo Instrument Co. announce that they are now in full production with their "Unitag" tag assemblies. These enable stand-off insulators and tag strips to be built up by the user to suit individual needs.

They are built up along 6 B.A. screws or studding using the bakelite bushes as spacers between the tags. The bushes



have hexagonal interlocking sections which prevent rotation and also permit three alternative orientations of the tags.

"Unitags" are supplied loose in lots of 100 pairs of bushes and tags. Preassembled units complete with mounting brackets can also be obtained from Harwin (Engineers) Ltd., 101 Nibthwaite Road, Harrow, Middlesex.

McMurdo Instrument Co Ltd,
Victoria Works,
Ashtead, Surrey.

Soldering Iron Bits

SOLDERING iron bits having a corrosion resistive metal coating are being manufactured in a variety of sizes by B & P Radio. It is claimed that these bits have a life 7 to 10 times greater than an ordinary copper bit and that bit changing is facilitated since seizure between the bit and the soldering iron is eliminated.

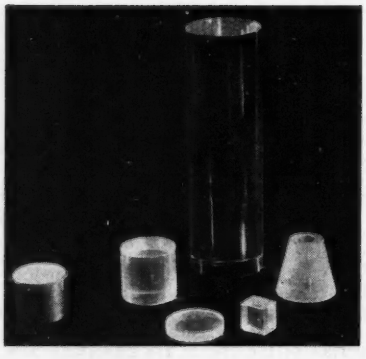
B & P Radio Ltd,
Langham Parade,
Tottenham,
London N.14.

Scintillation Phosphors

(Illustrated below)

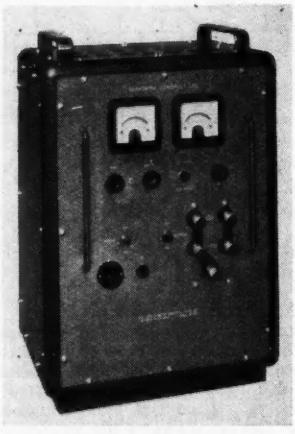
ISOTOPE DEVELOPMENTS have now increased their range of scintillation phosphors to include the new, high-activity scintillator, "Pamelon".

This material, which gives good light response and other essential characteristics, provides an overall phosphor which is comparable with many of the present crystalline materials that are difficult to grow and fabricate. The energy yield and fast decay time of "Pamelon", coupled with its availability in large sections, at low cost, make it a versatile scintillator for use in connexion with alpha-, beta-, gamma- and X-rays.



Another item of interest to workers in the nucleonic field is the "I.D.L." ready-for-use sodium iodide capsule. Difficulties have been encountered in the past where the hydroscopic raw crystal has been supplied to customers and wastage has occurred in their having to polish and encapsulate the crystal. The "I.D.L." range of capsules includes a cylindrical crystal to give optimum response from the standard British photomultipliers, as well as smaller capsules containing cubic crystals for directional scintillation heads.

Isotope Developments Ltd,
Finsbury Pavement House,
120 Moorgate,
London, E.C.2.



Low Voltage Stabilized Supply

(Illustrated above)

THE type 38 electronic voltage stabilizer will supply 0 to 2·5A at from 0 to 15V. The stability is such that a mains fluctuation of ±10 per cent causes a change of output not exceeding 5mV. The output ripple is not more than 3mV r.m.s. under the worst conditions. The time for full correction of mains changes or small load current changes is about 1msec. The reference voltage for the unit is supplied by a Mullard 85A2 used in a balanced d.c. amplifier circuit.

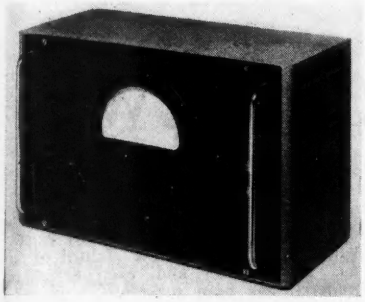
Servomex Controls Ltd,
Crowborough Hill,
Jarvis Brook,
Sussex.

Ohmmeter

(Illustrated above right)

THE Ohmmeter Type 861 is intended for production and laboratory continuity testing, and enables the value of any resistance between 1Ω and 10MΩ to be rapidly determined. A large meter, having a scale length of approximately 7in is employed.

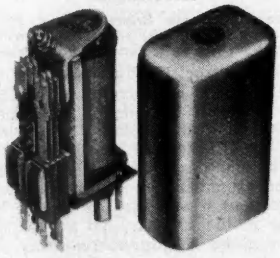
The instrument operates from normal a.c. mains supply, the d.c. test voltage



being obtained from an internal stabilized source. Six resistance ranges are provided, each range, selected by push-button switching, being a multiple of the meter reading, except in the case of the highest range which has a separate scale calibrated from 0·1MΩ to 10MΩ.

The instrument is suitable for bench use or for mounting in a 19in. rack.

Airmec Ltd,
High Wycombe,
Buckinghamshire.



Relay

(Illustrated above)

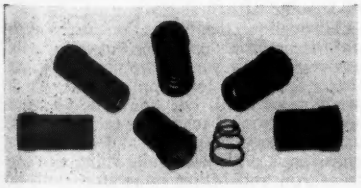
THE type 2 400 relay, the latest addition to the range manufactured by Magnetic Devices, has been designed to suit present day electronic circuits both as regards size and sensitivity. Measuring only 2¼in high by 1in by 1¼in, the contacts are readily accessible on removal of the dust cover and all connexions are made from the underside. Both light and heavy duty contacts are available and a sensitivity of 4mA with a 10kΩ coil has been achieved with adequate contact clearance and pressure.

Magnetic Devices Ltd,
Exning Road,
Newmarket.

Valve Screens

(Illustrated below)

A NEW range of valve screens, with associated coil springs have been made by Plessey for use in conditions requiring robust components with efficient performance under tropical conditions.



The screens are available in two diameters to suit B7G or B9A valveholders, and in the three standard lengths recommended by the Radio Components Standardisation Committee.

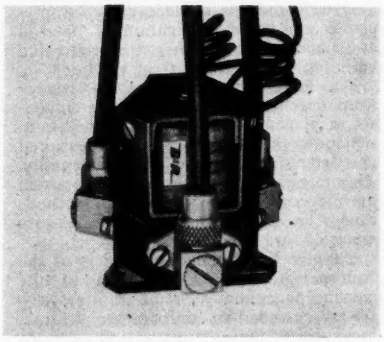
They can be supplied in either brass for use with silver plated valve skirts, or aluminium with cadmium plated skirts. In the case of brass screens, the contacting face is silver plated, but with aluminium screens the contacting face is clean metal. In either case the remaining inner surface and the whole outer surface are protected by a matt black stove-enamelled finish which assists in dissipating the heat generated in the valve.

The Plessey Co Ltd,
Ilford, Essex.

Coaxial Relay

(Illustrated below)

THE coaxial relay type A.07 is for use inside apparatus where space is limited. Instead of the normal plug and socket arrangement connexion to the relay is by lengths of coaxial cable brought straight out through fittings which allow them to emerge in any desired direction. The action of the relay can either be simple changeover or changeover and earth, i.e., the unused line can be earthed to minimize cross-talk.



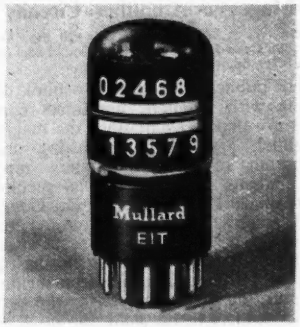
Besson & Robinson Ltd,
6 Government Buildings,
Kidbrooke Park Road,
London, S.E.3.

New Valves

(EIT Illustrated above right)

MULLARD have recently commenced manufacture of a high speed decade counter tube. This tube, the EIT is of the hard-vacuum type and is, therefore, capable of very high counting speeds; counts of 30 000 per second being readily attainable.

The basis of the Mullard EIT is a ribbon-shaped electron beam which can be deflected into ten well defined positions by the input signals. In any of these ten positions the beam passes through one of ten apertures in a cylindrical anode and impinges on a fluorescent screen, causing a spot of light to appear opposite the appropriate figure



"0" to "9") marked on the tube envelope. As the last position is passed by the beam a signal can be generated to re-set the tube to "0" and simultaneously apply a counting pulse to the next tube in the chain.

"Special Quality" versions of the voltage reference tubes types 90C1, 85A2 and 150B2 are now being made available. The new tubes are tested to withstand impacts of 500*g* and vibrations of 6*g* at 175c/s. They are available in two forms, one with pins and one with flying leads. The M8098 (pins) and M8142 (flying leads) are electrically equivalent to the 85A2; the M8206 and M8207 to the 90C1 and the M8163 and M8208 to the 150B2.

Mullard Ltd,
Century House,
Shaftesbury Avenue,
London, W.C.2.

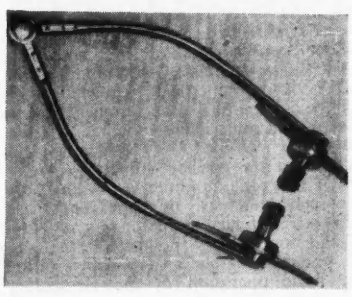
Stethophones

(Illustrated below)

STETHOPHONES (Foot's induction phones) are earphones which have no trailing wires and are not plugged in to a point. They are operated by the magnetic field set up by a wire or copper tape encircling the area in which they are to be used, thus the wearer has complete freedom of movement. An audio power of some 3 to 4W is adequate to cover an area of 200 to 500ft².

They are intended primarily for aiding deaf people in cinemas, churches, etc., and for use in hospitals. For the latter purpose a special type (illustrated) are made having short extensions which are made to revolve so that the pole pieces always remain in a vertical position (for maximum sensitivity) even when the wearer is lying down.

The Magnetic Broadcasting Co Ltd,
Suffolk Hall,
1 Upper Richmond Road,
London, S.W.15.



BOOK REVIEWS

Magnetic Amplifier Circuits

By Dr. W. A. Geyger. 277 pp. 120 figs. Demy 8vo. McGraw-Hill Publishing Co. Ltd. 1954. Price 42s. 6d.

THE publication of any new book dealing with magnetic amplifiers constitutes a welcome event since the magnetic amplifier art, though boasting many thousands of technical papers, reports and patent specifications, is peculiarly short of works of reference. Dr. Geyger's book covers the field in a comprehensive manner, but it falls short in some respects of the aims expressed in the closing paragraphs of his preface. Far from being an introduction to the subject for the benefit of newcomers to the field, the book is of greater use to engineers already possessing a wide experience of magnetic amplifiers. This derives from the fact that the emphasis is placed very markedly, as the title makes clear, on magnetic amplifier circuits, the material being presented without rigour and at "technician" level. The engineer finds a large selection of useful circuits which he can analyse in greater detail by methods well known in the art. The technician will obtain from the book a superficial knowledge of magnetic amplifier applications, and the student will most likely conclude that the subject is extremely involved and still wonder at the end of the book exactly how a magnetic amplifier works and how one sets about designing one. There are two extraordinary omissions in a book of this sort. Firstly, nowhere is there to be found a simple analysis underlining the basic operation of the elementary transductor in the transient and steady state condition, and secondly, the book is entirely without photographic illustrations of any sort. The newcomer, therefore, is unable to establish, except in a very nebulous way, the relationship between the multitude of circuits and their realization in a practical form.

The author has adopted a classification of magnetic amplifier types, and in general a chapter is devoted to each one of these. He makes the broad distinctions between "non-feedback", "internal feedback", and "external feedback" types and sub-divides these according to the number of cores required and the nature of the output signal, e.g. "Duo-directional half-wave output". This, as the author mentions, is just one of several forms of classification, and though it works tolerably well, there is of necessity an appreciable amount of duplication of material and some paragraphs are reiterated verbatim in several parts of the book.

The book offers only slight assistance in matters of design and here the emphasis is placed upon the "load line" construction based on non-dimensional characteristics obtained experimentally. This technique has now been superseded by more refined mathematical methods except in cases when low grade core materials are used.

Chapter X introduces amplifiers of the "internal feedback" type and in the ensuing pages many circuit arrangements are discussed. An unfortunate feature, however, is that no distinction is made between inherent "half cycle" response amplifiers and those of a more conventional sort. It is the reviewer's opinion that the terms "control current" and "control voltage" are not always used in the right places and occasionally misleading generalizations are made. For example, on page 149 a group of single-core circuits is shown and lower down on the page it is stated that a power gain of 10^6 or 10^7 may be obtained with such arrangements. In fact, the circuits shown might yield power gains of perhaps 100 but hardly any more. One must go to the well-known auto-excited shunt amplifier (mentioned in the following chapter) in order to obtain the high gains referred to by the author.

The book closes with three chapters entitled "Second Harmonic Circuits", "Technical Properties of Magnetic Amplifiers", and "Typical Applications of Magnetic Amplifiers". The first of these gives a short account of various magnetic modulator arrangements, and though stressing the great zero stability obtainable from these, fails to give any clue why this should be. The next chapter, consisting of seven and a half pages, lists a dozen features applicable to magnetic amplifiers in general and offers some very brief notes on time-constant and illustrates a method for measuring this. The final chapter, also a short one, comes as a considerable anti-climax since the only application discussed in any worthwhile detail concerns the control of an a.c. servo motor and, even here, the material has been substantially covered in earlier chapters.

Broadly speaking, it is considered that Dr. Geyger's book represents a useful addition to the literature and the copious references at the end of each chapter add materially to its value. It is recommended to all those actively engaged in the application of magnetic amplifiers, but others will not derive the benefits the book has to offer until they themselves have fully grasped the basic principles governing the magnetic amplifier behaviour.

A. E. MAINE.

VOLTAGE STABILIZERS

By

F. A. Benson, M.Eng., A.M.I.E.E., M.I.R.E.

(University of Sheffield)

Price 12/6

(Postage 6d.)

This monograph describes the various devices employing saturated elements, glow-discharge tube circuits and thermionic valve arrangements for voltage stabilization. A comprehensive bibliography is included.

Order your copy through your bookseller or direct from

Electronic Engineering

28 ESSEX STREET, STRAND, W.C.2

Electronics

By Thomas Benjamin Brown. 545 pp. 396 figs. Demy 8vo. John Wiley & Sons, New York. Chapman & Hall Ltd., London. 1954. Price 60s.

IN his preface, the author of this publication, who is Professor of Physics at the George Washington University, answers his own question, "Why another book on Electronics?", by explaining that among the wealth of literature he has been unable to find any book which by itself is a suitable text for a basic course in the subject. To try to satisfy this need he has drawn on many years of teaching experience and presented the information given to his own students. This includes physical, analytical and graphical explanations of the phenomena encountered in electronic devices, illustrated by 43 "demonstration experiments", 37 "experiments" (carefully designed and detailed) and 266 original problems. Undoubtedly his course in Electronics is an excellent one, but is his book "planned to meet the needs of the classroom and the laboratory", best suited to the requirements of students taking courses under other teachers? The experiments, interspersed with the text, although providing many good suggestions for instructors, might be irritating to a reader using the book for collateral study, and their omission (on the grounds that similar work will be included in any well-designed course) would have allowed, within the same compass, certain sections to be explained in greater detail. For example, the dependence of the conditions for oscillation on valve characteristics is not developed, and there is an interesting method of graphical analysis for a radio-frequency amplifier (Chapter X, Section 13), which might be difficult to understand at a first reading.

Throughout the book, the emphasis is on the internal operation of electronic devices in their various applications, and there are very few applications which are not included, but one would expect some mention of television camera tubes, as the theory of photo- and secondary-emission is dealt with quite fully, and the transitron and Miller integrator, both of

which depend on fundamental valve properties.

The development is from the characteristics and uses of diodes, through triodes, tetrodes and pentodes, feedback circuits, oscillators, special functions (differentiators, integrators, reactance valves, mixers, "flip-flops", etc.) to modulation processes, u.h.f. electronics and electronic instruments, with three chapters near the middle of the book on electron emission and the effects of gas in two- and multi-electrode tubes. These chapters are in greater detail than is usually found and the treatment is good, although one may wonder if the average student has sufficient background of pure physics for complete understanding. The forty-four pages on u.h.f. electronics give an up-to-date and adequate account of the progress in this field including the klystron, magnetron and travelling-wave tube.

The appendices contain notes on laboratory procedure and equipment, units, tube data (essential for the solution of many of the problems) and two (Schottky effect, and crystal rectifiers and transistors) which might be better incorporated in the text.

The considerable use of graphical methods of explanation is a valuable feature and the associated diagrams, and circuits, are clearly drawn, but there are some omissions, misprints, and variations as between symbols used in the text and on diagrams.

This is a useful book, probably more so to teachers than students and in this respect not quite successful in fulfilling the aims of the author.

A. W. HARRIS.

Audio Frequency Power Measurements

16 pp., 8 figs. Demy 8vo. Her Majesty's Stationery Office. 1954. Price 1s.

THIS booklet is number 8 in the series of "Notes on Applied Science". The series is produced by the National Physical Laboratory to provide industrialists and technicians with information on various scientific and technical subjects which is not readily available elsewhere. This particular booklet deals with power measurements by means of electrostatic, thermal and electrodynamic wattmeters, over the range 25c/s to 30kc/s, approximately the audio frequency range.

The electrostatic instrument is delicate and has a slow response, but is singularly free from frequency or power factor errors. It has been calculated that there is no significant error in the instrument itself at any frequency less than 1Mc/s. In practice there are errors in the auxiliary resistors which, at present, limit the maximum frequency for accurate measurements to about 30 000c/s.

The accuracy of the thermal wattmeter is dependent on the law of response of the thermo-junctions used and is very much less than that of the electrostatic instrument. It is, however, cheap and its errors are not usually dependent on frequency up to about 30 000c/s, when the quality of the auxiliary resistors may impose a limit.

The electrodynamic wattmeter is robust and has a quick response. It is the most suitable of the three types for general measurements. There is, however, considerable difficulty in maintaining accuracy at the higher frequencies. If, however, feedback amplifiers are used to supply the wattmeter coils it is possible to construct an instrument with the same upper frequency limit (30 000c/s) as the electrostatic and thermal types.

Crystal Rectifiers and Transistors

Edited by M. G. Say. 168 pp. 152 figs. Demy 8vo. George Newnes Ltd. 1954. Price 21s.

THIS book, as explained in its preface, has been made up from information already published or supplied by the several firms now producing semi-conductor devices.

While the average general reader will welcome any book that saves him having to hunt through numerous periodicals and makers' data sheets in order to cover the subject, it must be realized that knowledge is being gained in this field at such a rapid rate that the situation changes even between a piece of development work being completed and its subsequent original publication.

The additional time lapse necessary to republish all the collected information in book form cannot but increase this drawback.

Dr. M. G. Say has collected together an array of facts, manufacturers' data and tables, but he has given very little indication of their relative positions and merit in this new field.

Furthermore, the book brings together much of what has been said in the past, without at the same time giving indication of the present situation or future trends.

Separate chapters are provided on fundamental semi-conductor matters, silicon crystal rectifiers, germanium crystal rectifiers, point contact transistors, junction transistors, transistor testing, photo transistors and applications.

The last chapter, "Applications", is particularly disappointing to circuit designers, crying out for information on the method of selecting transistor operating conditions, on the choice between one type and another, and on the likely spread of characteristics with time, temperature and transistor to transistor. The book confines itself to very generalized statements, and the approach is descriptive rather than analytical.

While the book is certainly useful it could so easily have been much better.

G. GRIMSDELL.

Automatic Digital Computation

National Physical Laboratory. 296 pp. Demy 8vo. Her Majesty's Stationery Office. 1954. Price 21s.

THE International Symposium on Automatic Digital Computation held at the National Physical Laboratory, Teddington, in March, 1953, was the third of its kind in this country. These summarized reports on the discussions are based on notes taken at the time by the various reporters, checked and supplemented by reference to a magnetic tape recording of the proceedings. It has, of course, been necessary to condense the reports of the discussions in order to keep the record to a reasonable size.

CHAPMAN & HALL

Just Out

ELECTRO-ACOUSTICS

The Analysis of Transduction and its Historical Background

by

Frederick V. Hunt

Professor of Physics and of Applied Physics, Harvard University

260 pages *52 figures* *48s. net.*

DIELECTRICS AND WAVES

by

Arthur R. von Hippel

Professor of Electro-Physics, Massachusetts Inst. of Technology

284 pages *Fully illustrated* *128s. net.*

37 ESSEX STREET, LONDON, W.C.2

Smith's for Technical Books

Books on the theory and practice of electronics, new developments, circuit design, and other specialized subjects can be quickly supplied through your local Smith's shop or bookstall.

Your copies of ELECTRONIC ENGINEERING can be bound into attractive volumes; and all your stationery and printed matter supplied through our local branch.

W. H. Smith & Son

for **SPECIALIST BOOKS**

HEAD OFFICE: STRAND HOUSE, LONDON, W.C.2

Microwave Theory and Techniques

By H. J. Reich, P. F. Ordung, H. L. Krauss and J. G. Skalnik. 878 pp. 150 figs. Demy 8vo. D. van Nostrand Co. Inc., Toronto & New York. Macmillan & Co., London. 1954. Price 75s.

THE branch of engineering which deals with radio frequency energy at centimetre wavelengths is extremely well documented, and in the last eight years a wealth of new material has been published. Even so, "Microwave Theory and Techniques" by Reich, Ordung, Krauss and Skalnik is a welcome addition to the available literature on this subject. Its 900 pages present clearly and logically a comprehensive treatment of the fundamentals of electromagnetic theory underlying electronic engineering at microwave frequencies, together with a competent review of current practice. The book will provide nothing intrinsically new to the established engineer working in this field, but gives the present state of knowledge in such a lucid and complete way that it will certainly be a "jumping-off ground" for new thought and development; to quote the authors' preface, "This book is intended primarily as a textbook for a senior or first-year graduate course in microwaves. It may also be useful to research workers and practising engineers as a reference book."

After an introduction of 30 pages devoted to vector analysis, there are two excellent chapters of electromagnetic fundamentals. There is no novelty in the approach, but the reader is carried "painlessly" through the theory necessary for the understanding of the arguments developed later in the book. The authors, in all their theoretical explanations, have the rare gift of making the relatively complicated seem simple; how often the reverse is the case in technical literature! As a sound academic approach to transmission lines, the third chapter cannot be equalled, and this is followed by a similarly good chapter on impedance matching. The Smith impedance chart is used frequently in these chapters to explain the matching techniques described.

The hundred pages comprising the chapter on "Waveguides" are in some ways a little disappointing. The theoretical explanation of waveguide propagation by the application of boundary conditions to the solutions of Maxwell's equations is well done. The reviewer considers, however, that the physical explanation of this propagation in terms of an analysis of the interference pattern formed by successive reflexions in the waveguide, frequently quoted from Southworth is unnecessary, as is the description of the various hypothetical devices for launching higher order modes, also quoted from the same source. The analysis of the single-wire surface waveguide is carried out well.

In writing the practical chapters, namely those on "Waveguide and coaxial components", "Antennas", "Measurements" and "Microwave resonators" the authors were faced with the dilemma of writing an up-to-date progress report of current developments or of explaining the simple ideas and problems of engineering at centimetre wavelengths. The first course has the obvious danger of obsolescence in a very short time; in the second case, the appeal of the text would be restricted to the student and the newcomer. A fair compromise has been reached by basic descriptions occasionally illustrated with modern practice. There is only the briefest mention of the manufacturing aspect of microwave components and devices; ease of manufacture, and ability to be reproduced accurately are cardinal features of microwave engineering.

The remainder of the book gives a full account of valves for use at centimetre wavelengths as amplifiers and oscillators. In particular, the authors deal with microwave triodes and tetrodes, klystrons, travelling wave tubes and magnetrons. The theory of operation of each type of valve is developed, including the results of analysis of magnetron operation carried out by Hartree's mathematical group, but this theory is purposely of a simplified nature. A number of particular examples of valve are examined, and their characteristics, use, performance and structure described. The valves are of American origin in every case. This section of the book, dealing with valves, is obviously directed more to the student than to the established engineer.

Each chapter is well provided with examples and a comprehensive bibliography, together with references interspersed in the text. The bibliography is particularly useful, since in many cases the authors could only give brief attention to interesting points. An excellent feature is the index of mathematical symbols which appears at the end of the book. All the symbols used in the book are listed together with the page of the text on which each is defined. The typography throughout is of a poor standard, and one feels that more photographs would have been helpful. On the whole, however, "Microwave Theory and Techniques" deals fully and adequately with what has become a very wide subject, and is certainly one of the best books of its kind published to date.

J. W. SUTHERLAND.

Electrical Measuring Instrument Practice

By E. H. W. Banner. 130 pp. 40 figs. Demy 8vo. United Trade Press Ltd. 1954. Price 15s.

BASIC electrical measuring instruments are not exactly the most glamorous equipments in the electrical world. Major Banner has therefore made no attempt in his book to speak of their charms. Instead, he has produced a small book giving a review of present-day practice of both the construction and the use of these instruments. Electronic instruments are not dealt with, except for a few cases of the very simplest type.

The book begins with a chapter giving useful facts on Standards and Specifications for instruments including Inter-Service Specifications. This information, which includes notes on sizes, shapes, and patterns, could prove useful to manufacturers as well as users. This is followed by some information on design points such as dial marking and scale shapes. There are also tables giving the functional analysis of the various types of indicating instruments, and showing the different parameters they could be made to measure when suitable transducers or auxiliary equipments are used.

All the different types of basic movements are described in some detail, followed by a description of special instruments such as power factor and frequency meters. This section forms a useful review of the various instruments on the market. Some information is then given on resistance measurement, but it is regrettable that the work of Evershed is not even mentioned in the bibliography.

The ranges and characteristics of the normal industrial double pivoted instruments are tabulated together with suggested types for various electrical measurements. The alternative approach to this choosing of a certain type for a particular measurement is, of course, the multi-range instrument. These are described, and an attempt is made to show how wide a field these may be made to cover.

The last chapter deals with the type of instrument perhaps best known as "test sets". Here we find descriptions of the type of instruments aimed specifically at a particular range of tests. The instruments themselves are often manufactured by assembling several individual instruments in the same case.

It is unfortunate that once again we have in this book a standard of illustration, particularly the drawings, which is much below that which we would expect to find in a book of this size and price.

J. R. BOUNDY.

A Guide to Amateur Radio

38 pp. Demy 8vo. 6th Edition. Radio Society of Great Britain. 1954. Price 2s. 6d.

THIS edition is completely new and up to date. The guide is intended chiefly for the newcomer to amateur radio who should find within its pages all that he needs to know about learning the morse code, studying for the Amateur Radio Certificate and obtaining an amateur radio licence. There is an extensive section on practical designs of transmitters and receivers.

Radio Laboratory Handbook

By M. G. Scroggie. 436 pp. 299 figs. Demy 8vo. 5th Edition. Iliffe & Sons Ltd. 1954. Price 25s.

THIS reference book on laboratory electronic techniques is intended for both professional engineers and amateurs. It first describes the layout and furnishing of an up-to-date laboratory, and then the various types of apparatus available. Both commercial instruments and improvised equipment are covered. Later chapters deal in detail with methods of making measurements and tests of every kind. Finally, a large section is devoted to general principles and reference material of everyday use to the radio engineer.

Television Simply Explained

By R. W. Hallows. 196 pp. 97 figs. Demy 8vo. 2nd Edition. Chapman & Hall Ltd. 1954. Price 10s. 6d.

THE aim of this book is to explain in simple language to ordinary non-technical people what television is and how it works. The author has a gift of making a difficult scientific subject easy for the ordinary mind by the apt use of analogy and by particularly lucid exposition.

Short News Items

The General Electric Co. Ltd. has been awarded a contract worth two and a half million dollars for extensions to the telephone system of Haiti, in the Caribbean, which for 150 years has been an independent republic. Besides extensions to telephone exchanges in Port-au-Prince and other towns, as a result of which some 3 300 new subscribers will be connected, the contract provides for the building of 500 miles of open wire trunk line routes.

An International Analogy Computation Meeting will be held in Brussels from 27 September to 1 October this year. This is being organized by the Societé Bélge des Ingénieurs des Telecommunications et d'Electronique, the Societé Belge des Electriciens and the Societé Belge des Mecaniciens. The Organizing Committee would like to know, as soon as possible, the names and addresses of those who intend taking part in this meeting as well as the form of participation, i.e., whether they intend submitting a paper, exhibiting equipment or simply attending the various functions. All communications should be addressed to M. P. Germain, Institut de Physique Appliquée, Université Libre de Bruxelles, 50 Avenue Franklin Roosevelt, Brussels.

Borough Polytechnic announce a course of five lectures on the writing of technical reports which will be given by Mr. G. Parr on Thursdays at 6.30 p.m. commencing on 20 January. The fee for the course is £1 1s. The course will cover the preparation of reports, collection of data and practical advice on the submission of papers and publications. Enrolment forms can be obtained from the Secretary, Borough Polytechnic, Borough Road, London, S.E.1.

The University of Liverpool, Department of Extra-Mural Studies, announce, among others, post graduate courses on the following subjects. An Introduction to Servomechanisms, on Tuesdays from 5.30-7 p.m. commencing 18 January. The Design and Analysis of Scientific Experiments, on Wednesdays from 7.30-8 p.m. commencing 12 January. The fee for each course is £2 2s. and enrolment forms may be obtained from the Director of Extra-Mural Studies, 9 Abercromby Square, Liverpool 7.

The Electro-Physiological Technologists' Association will be holding their next general meeting on Saturday, 5 February, at the National Hospital, Queen Square, London, W.C.1. The meeting will consist of papers and demonstrations of particular interest to electro-physiologists. Non members are welcome on application to Mr. G. Johnson, Hon. Secretary, Hurstwood Park Hospital, Haywards Heath, Sussex.

LEO Computers, a wholly-owned subsidiary of J. Lyons & Co., has now been formed, "to carry on the business of manufacturers of and dealers in all forms of electrical or automatic computors and office machinery and automatic control equipment, etc." It was seven years ago that Lyons began their investigation into the possibilities of harnessing electronic computors to everyday commercial office work, and since the beginning of 1954 LEO has been engaged in full-scale clerical work in Lyons offices. The new company will be marketing LEO at around £90 000, but medium-sized companies will also be able to profit from the new electronic office by renting time for individual jobs.

The Independent Television Authority has appointed Mr. P. A. T. Bevan to be its Chief Engineer. Since 1934 he has been a member of the Engineering Division of the BBC and latterly was a senior member of their Planning and Installation Department. He has been associated with most of their major engineering projects, and was one of the pioneer team responsible for developing the technical facilities for starting the BBC's Television Service from Alexandra Palace in 1936, and for its subsequent expansion. Since the war he has been mainly concerned with the development of v.h.f. broadcasting. Mr. Bevan is the author of a number of important papers in the radio and television field and has been awarded the Duddell Premium which is the premier award for radio work given by the Institution of Radio Engineers.

Marconi's Wireless Telegraph Co. Ltd. have recently shipped to Belgium a high power h.f. communication transmitter type HS.51. This transmitter has been manufactured for the Belgian R.T. and T.—the equivalent of the G.P.O.—and is to be installed by Marconi engineers at Ruisselede, Belgium.

The Third Biennial British Plastics Exhibition will be held at Olympia, London, from 1-11 June this year.

Redifon Ltd. of Wandsworth, are to supply equipment for a complete broadcasting station for Radio National de Peru. The station, which will be sited at Piura, is due to be opened in June.

The Royal Society have made the following awards of medals for 1954. The Copley Medal, Sir Edmund Whittaker. The Rumford Medal, Dr. C. R. Burch. The Royal A Medal, Sir John Cockcroft. The Hughes Medal, M. Rylie.

E. K. Cole Ltd. announce that Mr. A. J. Brunker is relinquishing his position as General Export Manager to become Chief Engineer of the Company. Mr. W. M. York, who as an Executive Director already controls Ekco Publicity and the Heating Division of the Company, will, in addition, now direct the E. K. Cole Ltd. export activities covering radio, television, plastics and cine equipment.

Honeywell Brown Ltd., manufacturers of industrial instrumentation and automatic controls for space heating, ventilating, and air conditioning, have opened an area office in Cardiff. The office is at 95 Exchange Buildings, Mount Stuart Square, Cardiff, and is under the supervision of Mr. L. G. A. Gabe.

Mr. F. H. McCrea has been elected chairman of the Dubilier Condenser Co. Ltd.

Furzehill Laboratories Ltd. have transferred their Head Office, including their Sales, Accounts and Designs Section, to new and more extensive premises at 57 Clarendon Road, Watford, to which all sales and technical inquiries should be addressed in future. The telephone number is Gadebrook 4686.

Silentbloc Ltd., manufacturers of flexible bearings and anti-vibration devices, have vacated their premises in the Notting Hill Gate district of London for a new factory at Crawley. All correspondence should now be addressed to Manor Royal, Crawley, Sussex.

The Directors of Associated Technical Manufacturers Ltd. announce that the Company's name has been changed to Permanoid Ltd.

BINDING OF VOLUMES

Arrangements for the binding service are being continued this year, and the 1954 volume can be bound at an inclusive charge of £1.

Copies will be bound, complete with index and with advertising pages removed, in a good quality red cloth covered case blocked in gold on the spine.

Home and Overseas readers who wish to have their copies bound are asked to comply with the following instructions :—

(1) Tie the twelve issues (January to December, 1954) securely together before parcelling.

(2) Enclose a remittance for £1 and a gummed label bearing the sender's name and address.

(3) Enclose the copies, remittance and label in a closed parcel and address to :— The Circulation Dept. (E.E. Binding), 28, Essex Street, Strand, London, W.C.2. (No other correspondence is necessary.)

* * * *

The following are also available from our Circulation Dept. :—

A limited number of Bound Volumes for 1953 & 1954. Price, Two Guineas, post free.

Binding Cases for twelve issues. Price 5s., postage 6d.

The Index for Volume XXVI (1954) free.

Meetings this Month

THE BRITISH INSTITUTION OF RADIO ENGINEERS

Date: 26 January. Time: 6.30 p.m.
Held at: The London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.
Lecture: A Survey of Tuner Designs for Multichannel Television Reception.
By: D. J. Fewings and S. L. Fife.

West Midlands Section

Date: 12 January. Time: 7.15 p.m.
Held at: Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton.
Lecture: Electronics in Materials Handling.
By: L. Landon Goodman.

North Eastern Section

Date: 12 January Time: 6 p.m.
Held at: Neville Hall, Westgate Road, Newcastle upon Tyne.
Lecture: Some Circuits Associated with Wave Form Monitors.
By: E. T. Warburton.

Merseyside Section

Date: 6 January. Time: 7 p.m.
Held at: The College of Technology, Byrom Street, Liverpool, 3.
Lecture: Some Interesting Applications of Electronics to Photography.
By: D. M. Neale.

North Western Section

Date: 6 January. Time: 7 p.m.
Held at: Reynolds Hall, College of Technology, Sackville Street, Manchester.
Discussion: Problems in the Design and Production of Car Radio.
Opened by: C. L. Caiger.

South Wales Section

Date: 12 January. Time: 6.30 p.m.
Held at: The Glamorgan Technical College, Treforest.
Lecture: Electronic Counting Devices.
By: F. H. Gage.

Scottish Section

Date: 13 January. Time: 7 p.m.
Held at: The Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow.
Discussion: Channel III Commercial Television.

THE BRITISH SOUND RECORDING ASSOCIATION

Date: 21 January. Time: 7 p.m.
Held at: The Royal Society of Arts, John Adam Street, London, W.C.2.
Lecture: High Fidelity Reproduction.
By: N. C. Mordaunt.

THE INSTITUTION OF ELECTRICAL ENGINEERS

All London Meetings, unless otherwise stated, will be held at the Institution, commencing at 5.30 p.m.

Radio Section

Date: 12 January.
Lecture: Thermionic Valves of Improved Quality for Government and Industrial Purposes.
By: E. G. Rowe and W. W. Wright.
Date: 24 January.
Lecture: Radio Aids to Navigation.
By: F. J. Wylie.

Measurements Section

Date: 18 January.
Discussion: The Human Operator in Closed Loop Control Systems.
Opened by: C. Holt Smith.

Faraday Lecture

Date: 27 January. Time: 6 p.m.
Held at: Central Hall, Westminster, London, S.W.1.
Lecture: Courier to Carrier in Communications.
By: T. B. D. Terroni.
(Admission by ticket obtainable from the Institution.)

North Western Centre

Date: 18 January. Time: 7.30 p.m.
Held at: The Free Trade Hall, Manchester.
Faraday Lecture: Courier to Carrier in Communications.
By: T. B. D. Terroni.

North Western Measurements Group

Date: 25 January. Time: 6.15 p.m.
Held at: The Engineers' Club, Albert Square, Manchester.
Lecture: Current Summations with Current Transformers.

North Western Radio Group

Date: 5 January. Time: 6.45 p.m.
Held at: The Engineers' Club, Albert Square, Manchester.
Lecture: The Experimental Synthesis of Speech.
By: W. Lawrence.

South Midland Centre Radio Group

Date: 24 January. Time: 6 p.m.
Held at: The James Watt Memorial Institute, Great Charles Street, Birmingham.
Lecture: Some Applications of Electronics to Telecommunications.
By: C. E. Calverley.

South Midland Supply and Utilization Group

Date: 10 January. Time: 6 p.m.
Held at: The Imperial Hotel, Birmingham.
Lecture: A Brushless Variable Speed Induction Motor.
By: F. C. Williams.

Rugby Sub Centre

Date: 11 January. Time: 7 p.m.
Held at: The Temple Speech Room, Rugby.
Faraday Lecture: Courier to Carrier in Communications.
By: T. B. D. Terroni.

Southern Centre

Date: 12 January. Time: 6.30 p.m.
Held at: The University, Southampton.
Lecture: Mechanical Aspects of Aircraft Generation Equipment.
By: W. R. Hinton.
Date: 21 January. Time: 6.30 p.m.
Held at: R.A.E. Technical College, Farnborough.
Lecture: The Possibilities of a Cross-Channel Power Link between the British and French Supply Systems.
By: D. P. Sayers, M. E. Laborde and F. J. Lane.
Date: 28 January. Time: 6.30 p.m.
Held at: The Technical College, Weymouth.
Lecture: Transistor Circuits.
By: G. B. B. Chaplin.

Oxford District

Date: 12 January. Time: 7 p.m.
Held at: The Demonstration Room, Southern Electricity Board, 37 George Street, Oxford.
Lecture: The Future of Electronics in Industry.
By: E. R. Davies.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Date: 11 January. Time: 5 p.m.
Held at: The Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2.
Lecture: Electronic Switching and Common Control in Auto Exchanges.
By: T. H. Flowers.

RADIO SOCIETY OF GREAT BRITAIN

Date: 28 January. Time: 6.30 p.m.
Held at: The Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2.
Presidential Address.

TELEVISION SOCIETY

Date: 19 January. Time: 7 p.m.
Held at: The Royal Institution, Albemarle Street, London, W.1.
The Fleming Memorial Lecture: The Perception of Colour.
By: W. D. Wright.

PUBLICATIONS RECEIVED

SILICONE INSULATING COMPOUND is a leaflet describing a non-melting silicone grease for waterproofing and insulating ignition systems and electrical equipment. Midland Silicones Ltd., 19 Upper Brook Street, London, W.1.

FREQUENCY SHIFT KEYING EQUIPMENT FOR RADIO TELE-TYPEWRITER APPLICATIONS is an illustrated brochure covering the Plessey Company's range of telecommunications equipment, produced in collaboration with International Aeradio Ltd. The Plessey Co. Ltd., Ilford, Essex.

DAWE INSTRUMENTS IN INDUSTRY describes how Dawe instruments aid production in various industries. Copies are obtainable free of charge from Dawe Instruments Ltd., 99 Uxbridge Road, London, W.5.

POLISH TECHNICAL ABSTRACTS in English and Russian, the first of which appeared recently, are to be issued quarterly by the Central Institute of Technical and Scientific Documentation, Warsaw.

EVERSHED PROCESS CONTROLLERS MARK 3 and EVERSHED ELECTRONIC PROCESS CONTROL are two brochures produced by Evershed and Vignoles Ltd., Acton Lane Works, Chiswick, London, W.4. They are available free of charge on application.

SELENIUM is a survey published by Her Majesty's Stationery Office for the Department of Scientific and Industrial Research. It reviews the sources, production and uses of this semi-metal which has become increasingly important to the electrical industry in recent years. Price 1s. 6d.

THE PSYCHOLOGY OF INVENTION IN THE MATHEMATICAL FIELD by Jacques Hadamard is a book which investigates the role of the unconscious, the relating between intuition and logic, and other aspects of scientific invention. It quotes extensively from letters and writings of more than forty persons. Dover Publications, Inc., 920 Broadway, New York, 10. Price $1.25.

EVERYBODY'S BOOK OF ELECTRICITY by R. Barnard Way is a revised edition of a first introduction to the principles of electricity and a simple explanation of modern electrical appliances and machines. Percival Marshall & Co. Ltd., 19-20 Noel Street, London, W.1. Price 3s. 6d.

RESEARCH DEVELOPMENT ACHIEVEMENT is a pictorial survey of recent activities of the General Electric Company in selected fields of endeavour. The General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2.

INVENTORIES OF APPARATUS AND MATERIALS FOR TEACHING SCIENCE, VOL. III PART 4 contains information about the organization of the teaching of electricity at the Ecole Supérieure d'Electricité (France), The Royal Technical College, Stockholm, and in Great Britain. Each subdivision describes the general organization of the school and its teaching programme. Contents of the courses is given in detail, including lists of apparatus, equipment and machines. Unesco, 18 Avenue Kleber, Paris 16. Price 15s. 6d.

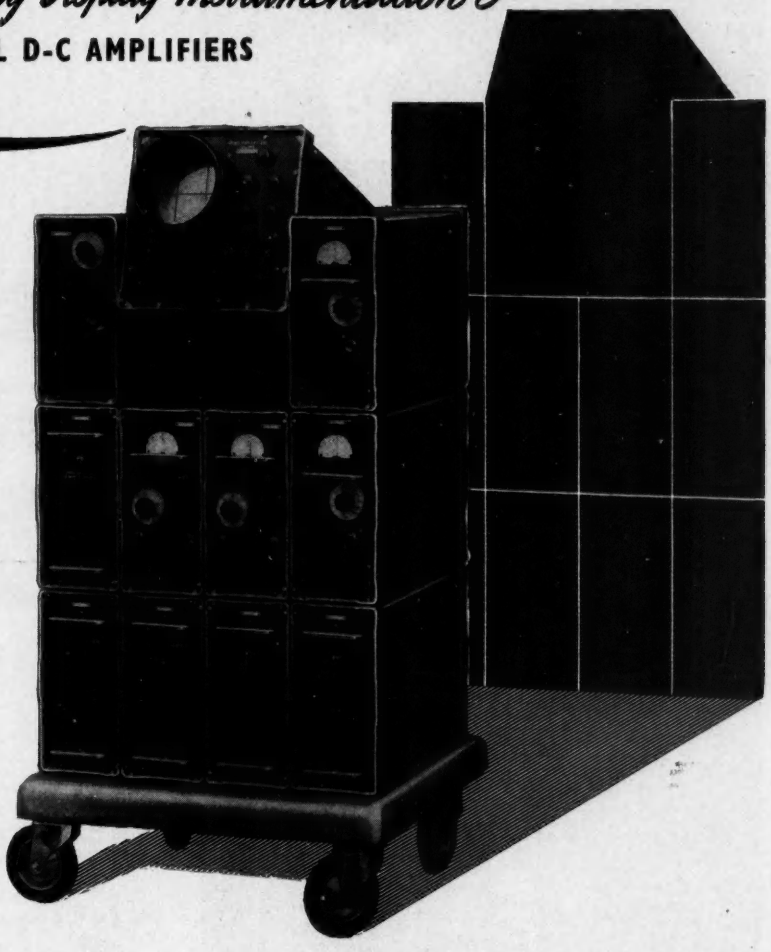
ROYCE ELECTRIC BOX TYPE FURNACES is a brochure describing these furnaces which are manufactured in two standard ranges, type RBM which is suitable for heat treatment processes up to a maximum temperature of 1000°C and type RBH for temperatures up to 1250°C. Royce Electric Furnaces Ltd., Sir Richard's Bridge, Walton-on-Thames, Surrey.

PYE SCIENTIFIC INSTRUMENTS is a catalogue which supersedes all previous issues and includes only those instruments in current production. W. G. Pye & Co. Ltd., Granta Works, Cambridge.

NAGARD UNITEL SYSTEM (Regd)

for Cathode Ray Display Instrumentation &

MULTI-CHANNEL D-C AMPLIFIERS



See what you measure!

The system is based on the use of unit instruments housed in cases of modular dimensions, each unit case being provided with holes arranged for its easy attachment to a neighbouring case with bolts. Thus may be built up a flexible assembly of co-operating instruments to fulfil a number of specific requirements yet capable of being easily changed to meet altered circumstances. Adequate ventilation of individual units is assured by the design of frame members. Few problems requiring Cathode Ray Display cannot be met by the Unitel System which is extremely versatile by virtue of the assembly method employed.

Cathode Ray units form the basic means of display and are available in single, double or four channel models each of which provides a self-contained power supply feeding the necessary potentials to the C.R.T. These Cathode Ray units are available separately. A 10 in. C.R.T. unit can be obtained for lecture demonstrations.

A Camera unit is available for either single shot or continuous film working. Time Base units for either single, double or four channel working and covering a wide range of cablibrated sweep speeds are available for coupling to C.R.T. units.

Y Deflection Amplifiers are also available in a wide variety of performance ranges each amplifier being complete with power supply. Careful design of multi-channel amplifiers enables the number of units required and the space occupied to be reduced to the minimum. Single, double or four channel workings are available ; six or more channels can be provided if necessary.

A typical trolley-mounted two channel installation is illustrated. This assembly has two sets of double channel D.C. amplifiers giving alternative conditions of high sensitivity or wide band up to 10 mc/s.

A wide range of units is available from current production ; special purpose units can be developed to meet almost any display problem.

The Unitel Installation grows with you

NAGARD LTD **18, Avenue Road, Belmont, Surrey** **VIGilant 0345**

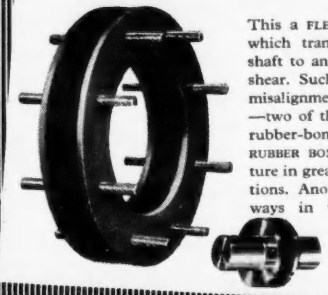
I

Two leading suppliers of engineered rubber under one roof

EMPIRE RUBBER COMPANY

RUBBER BONDERS LIMITED

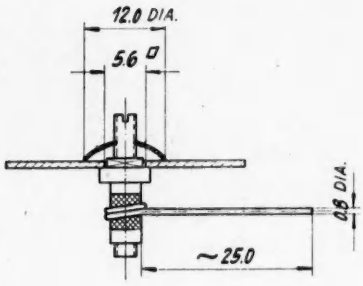
When it is a question of sealing . . . sealing doors, sliding roofs, lids . . . sealing cars, coaches, ships, aeroplanes . . . sealing to make things watertight, airtight, and everything-else-tight . . . the name to remember is EMPIRE RUBBER COMPANY. Examples illustrated here are typical of the Spandit range of solid skinned sponge rubber sections, available in every useful shape and size imaginable.



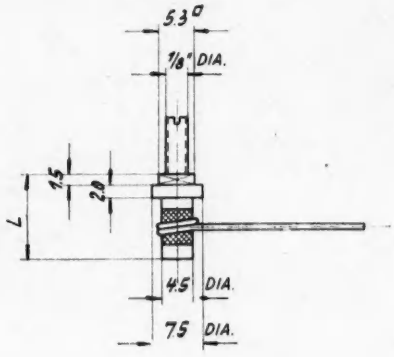
This a FLEXILANT SHAFT COUPLING which transmits torque from one shaft to another through rubber in shear. Such couplings accommodate misalignment and reduce vibration —two of the chief functions of the rubber-bonded-to-metal parts which RUBBER BONDERS LIMITED manufacture in great variety, to all specifications. Another example of the many ways in which RUBBER BONDERS LIMITED help machinery run more smoothly—and more economically.

R.B. 90

Ceramic Tubular Trimmer



With spring-clip.



Without spring-clip.

Rated voltage	500 V–/350 V ∿			
Testing voltage	750 V—			
Material	D 6 P 100		D 90 N 750	
Length L. ... ... m.m.	12	16	12	16
Regulating capacitance C min./C max. ... ... pF	0.5/3	1/5	3/10	3/15 4/20
Loss factor in 10^{-3} $tg\delta$ for C max. at 1 Mc and 20° C. ...	< 2			
Reactive current ... ... A	0,3			
Insulation resistance ... ... Ohms	$<10^{10}$			
Admissible dissipation ... ... mW	120			

TUBULAR TRIMMERS IN SPECIAL CERAMIC MATERIALS

Several types designed for greater stability to shock or vibration. Smaller, lighter, easier to mount, readily adjustable.

ST CON

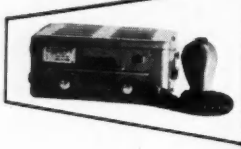
STEATITE INSULATIONS LTD.

25, Somerset Road, Edgbaston, Birmingham, 15.

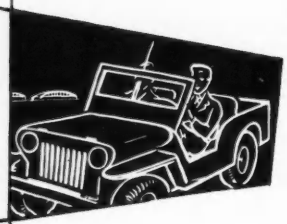
Tel : EDGbaston 3990. Telegraphic Address : "Steatite, Birmingham, 15."

RELIABLE

V.H.F.
Type 46



VERSATILE



V.H.F.
Type 68

EASY TO
MAINTAIN

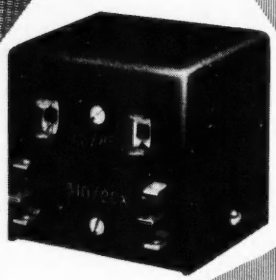
V.H.F.
Type 125/126

BRITISH COMMUNICATIONS
CORPORATION LIMITED
Second Way Exhibition Grounds, Wembley,
Middlesex. Telephone: Wembley 1212

The New P.A.R. Type 'M'
Miniature Power Relay

This new P.A.R. Power Relay features 2 change-over combinations each isolated in moulded housing to ensure long life and unsurpassed operating efficiency. Its concise physical dimensions of 1¾" x 1 3/16" x 1¼" give even greater scope to electronic apparatus manufacturers where economy of space is essential.

Compactness with exceptional Performance



Proved completely reliable after 500,000 operations

Maximum power capacity of the Type 'M' Relay is 2.5 Kilowatts or 5 amps at 250 VAC (10 each contact set at 110 volts A.C.) Power consumption of coils is .85 watts from 6 volts to 120 volts D.C. supply. Operate time at nominal applied volts is 25-40 millisecs. Mounting and terminal location arranged to specific requirements.

Literature with full details available on request.

Find out more about these other P.A.R. Products

Electronic Assemblies Transformers and Chokes
Vibratory Convertor Units Automatic Circuit Testers

If you have a problem connected with Electronic development or production, the P.A.R. Electronic Advisory Service can probably provide the answer . . . your enquiry will not commit you in any way.

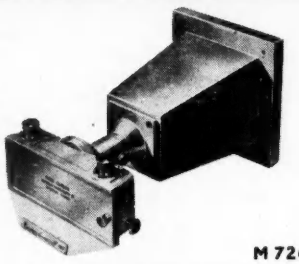
A Hopwood Product

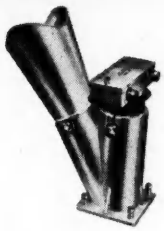
by P.A.R. Limited

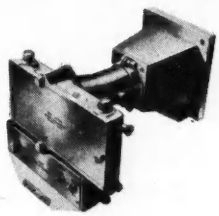
Specialists in the Design & Manufacture of Electronic Components

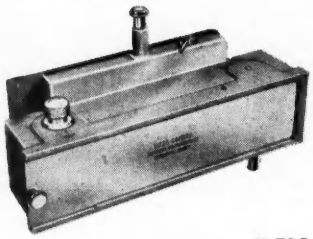
Talbot Works, Talbot Street, Nottingham. Tel: 46505/6

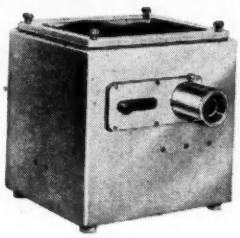
MINIRACK OSCILLOGRAPH RECORDING EQUIPMENT

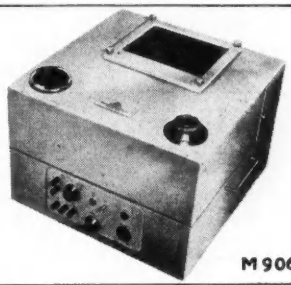

M 726

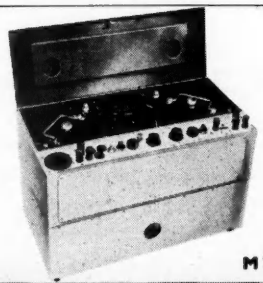

M 800

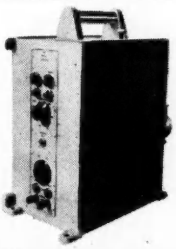

M 728

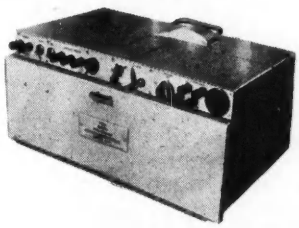

M 725


M 731


M 906


M 735


M 820


M 926

We manufacture the most comprehensive range of Oscillograph Recording Cameras in the world

Write for our Catalogue

SOUTHERN INSTRUMENTS LTD

CAMBERLEY SURREY

Telephone : Camberley 2230 (3 Lines) *Telegraphic Address : "Minrak," Camberley, England.*

Progress Report

Increasing demand for SenTerCel selenium rectifiers, germanium devices and SenTerCet equipment is evidence that these products are meeting the exacting needs of industry.

"Standard's" policy of continually improving quality and increasing production is expressed in a bold plan to move its Rectifier Division to a new factory in Harlow, Essex.

This factory, the largest in Europe built solely for the production of metal rectifiers, has been designed specifically to provide the particular facilities essential to the manufacture of these products.

Standard Telephones and Cables Limited

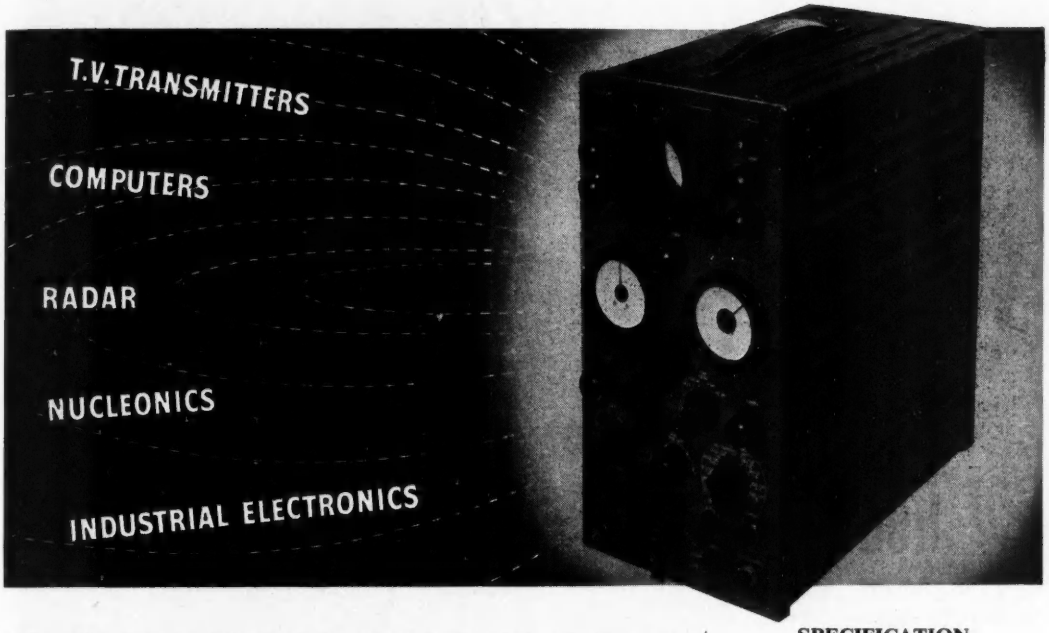
Registered Office: Connaught House, Aldwych, London, W.C.2

RECTIFIER DIVISION: Edinburgh Way, Harlow, Essex

Telephone: Harlow 26811 Telegrams: Sentercel, Harlow

E·M·I ELECTRONIC EQUIPMENT

FOR RESEARCH, DEVELOPMENT and TESTING



PORTABLE OSCILLOSCOPE TYPE WM.3.B.

A compact general purpose D.C. Coupled portable Oscilloscope with facilities for rapid precision time and voltage measurements. Volts and time meter presentation — no calibration markers required. Displayed waveform measured by voltmeter bridge system (visual null balance). 9 range voltmeter gives high accuracy readings unaffected by amplifier gain or linearity. Dual 'Y' input paths with attenuators afford signal comparison and mixing facilities. Floating circuit enables AC/DC signals to be measured with respect to D.C. potentials within ±500V.

SPECIFICATION

C.R.T. E.H.T. 0.8 & 1.2 kV.

'Y' Amplifier D.C. - 6 Mc/s.

MAX. SENSITIVITY
350 mm/V (at reduced bandwidth)

VOLTAGE MEASUREMENT
±10 mV to ± 500 V AC/DC
± 2½% F.S.D.

TIME MEASUREMENT
0.25 microseconds - 40 milliseconds

SWEEP DRIVE
Triggered or recurrent, phase and frequency selected

WRITING SPEED
6 milli-seconds/cm - 0.5 microsecond/cm

DISTRIBUTED AMPLIFIER TYPE 2B 50 c/s — 100 Mc/s

A unit designed for use with high speed Oscilloscopes to provide amplification over a very wide frequency spectrum at high output voltage levels.
The amplifier is extensively used in the study of high speed waveforms having rise times in the milli-microsecond range. It is being widely used with scintillation and coincidence counters, high speed scalers, and signal generators.

SPECIFICATION

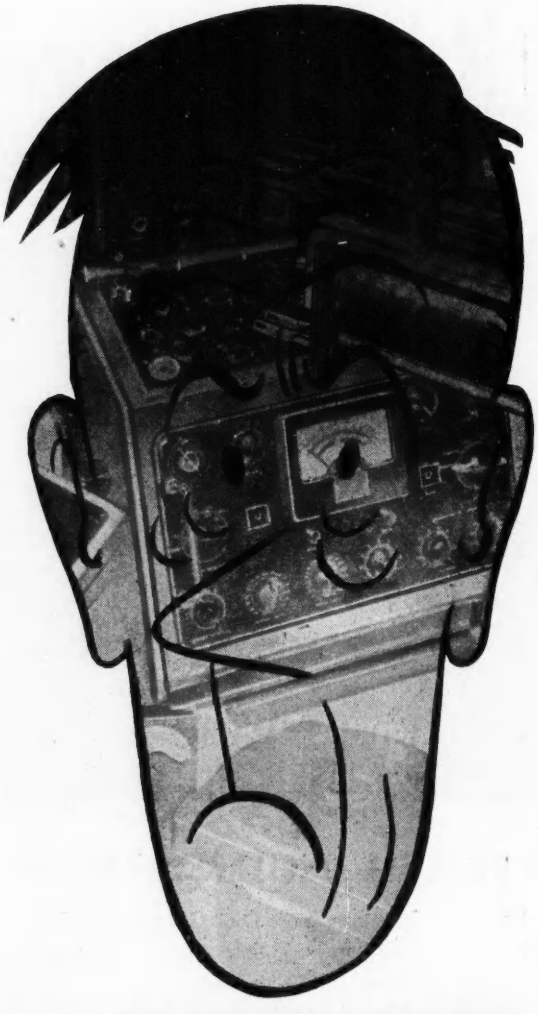
Input Impedance, 75 ohms. Output Impedance, 200 ohms nominal. Max. Output, 150 Vpp. Bandwidth, 50 c/s–100 Mc/s. Phase Response, Substantially linear over pass band. Gain, x 12.

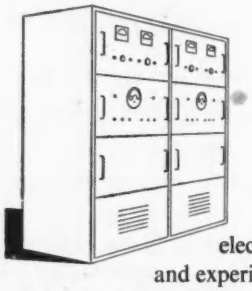
For further details write to:

E.M.I. FACTORIES LTD. HAYES, MIDDLESEX. Phone: Southall 2468
Ext: 857 & 655

EF. 98

Prepackaging need NOT be a headache





THE PREPACKAGING of electronic equipment calls for the skill and experience of the specialist. Salterpak *are* specialists, with wide experience in the field of electronics. This experience, plus the all-round efficiency of the Salterpak organisation, keeps prices remarkably keen—write for details of Salterpak service, which includes collection, packaging, clearance of all documents, and shipment to any part of the world. *** SAFER · QUICKER · CHEAPER**

The day's output, including much electronic equipment at No. 2 Factory.

SPECIAL STORAGE

The Ministry of Supply now require all electronic equipment and packing materials to be stored, prior to packing, in a temperature controlled chamber of low relative humidity.
We have installed special plant to meet with this important requirement.

SALTERPAK

(Ministry Approved)

The Prepackaging Division of

GEO. SALTER & CO. LTD., WEST BROMWICH

M-W.392

And NOW—a range of 'CERAMICAPS' for your LAB Storage Unit!

The LAB Continuous Storage Unit is widely acknowledged as the most efficient and convenient method of storing and selecting resistors. Now its usefulness is still further extended with the introduction of LAB pak'd 'Ceramicaps'. With the LAB Unit, research and experimental laboratories and small production groups have to hand immediately, a complete range of resistors and 'Ceramicaps', easily selected with card index simplicity from some 700 sorted and carded components. Empty cards are merely replaced with full ones from stock.

The LAB unit is supplied FREE with initial purchase to your specification. Standard assortments available. Each LAB Unit can be used to store one type of component exclusively, or quantities of the complete range of resistors and 'Ceramicaps'. Full details and illustrated list will be sent on application.

Ref.	Type	Loading	Max. Volts	Range	Dimensions
RESISTORS					
T	⅛ watt	⅛ watt	250	10 ohms to 10 megohms	⅜" × ⅛"
R	¼ watt	1 watt	500		¾" × ¼"
Tolerance available ± 20%, 10%, 5%					
HIGH STABILITY RESISTORS					
HS3	¼ watt	¼ watt	750	1 ohm to 500 megohms	1.1" × 0.1"
Tolerance available ±5%, 2%, 1%					
WIREWOUND RESISTORS 5 ohms to 100K ohms — 5 - 10 watts					
'CERAMICAPS' Tubulars 3 - 470 pf 500 - 5000 pf Tolerances ±2%, 10% Hi-K					

The Lab Continuous Storage Units are available from your normal source of supply, but more detailed information can be obtained from

THE LAB TESTED CONTINUOUS **STORAGE UNIT**

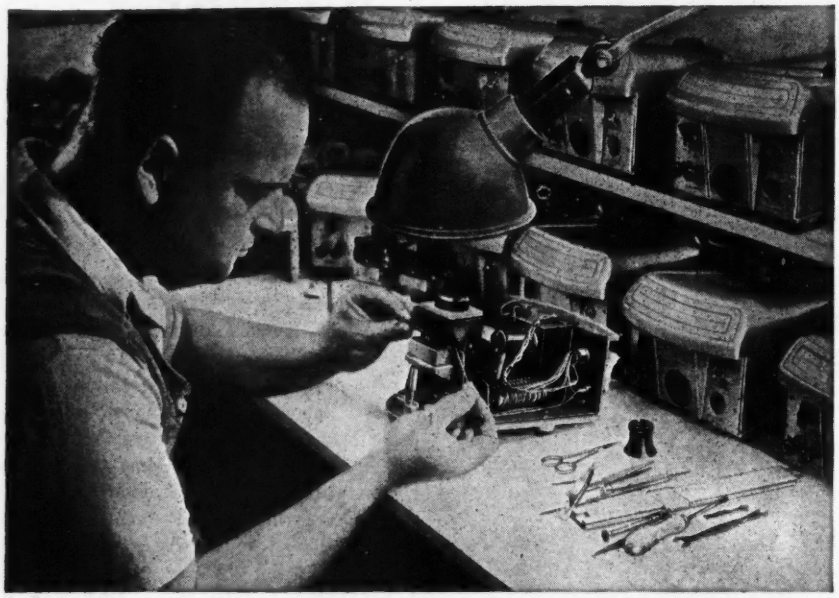
★ **Continuous Storage for Resistors and 'Ceramicaps'**

★ **Values separately carded**

★ **Finger-tip Selection**

THE RADIO RESISTOR COMPANY LTD

50 ABBEY GARDENS · LONDON · N.W.8 · Telephone: Maida Vale 5522



Built by Craftsmen ····· Assembly of Scalamp Galvanometers Cat. Nos. F.E. 7901/S-4/S

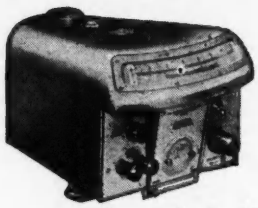
The

SCALAMP

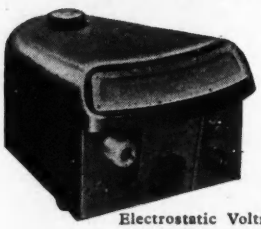
Range

You are invited to write for details of the instruments illustrated here.

The *Galvanometers* and *Electrostatic Voltmeters* are available in a range of sensitivities—the *Fluxmeter* has a very high performance and a unique return-to-zero device. Outstanding SCALAMP attributes include a truly functional dustproof case, mains or battery operation, and an easy-to-read hairline spot.



Fluxmeter Cat. No. E.E 8834



Electrostatic Voltmeter
Cat. Nos. E.E. 11308-11310

STANDARD EQUIPMENT IN MANY LEADING LABORATORIES

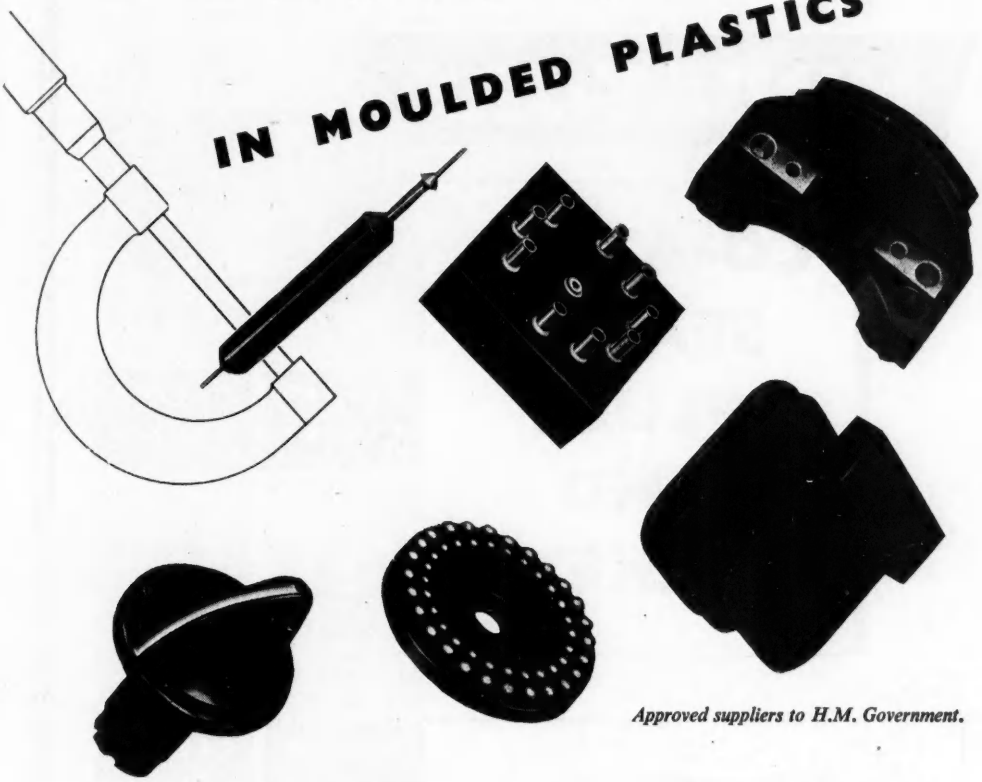
SCIENTIFIC PYE INSTRUMENTS

W. G. PYE & CO. LTD. GRANTA WORKS · CAMBRIDGE · ENGLAND

WG.54

INGENUITY with PRECISION

IN MOULDED PLASTICS



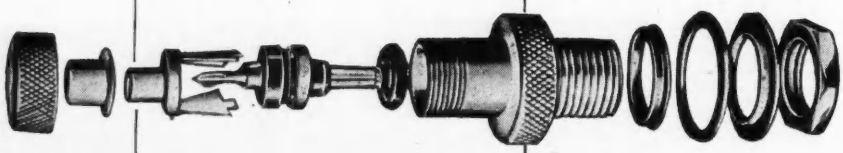
Approved suppliers to H.M. Government.

Leading industrialists and manufacturers have for many years known the quality and micrometer accuracy of PRESTWARE precision moulded components. A less widely appreciated side of the PRESTWARE organisation is our Technical Advisory Division whose services are at your disposal to solve your specific moulding problems and suggest fresh uses and applications. The extensive knowledge of our technicians can save you both time and money ; they will design and manufacture for you the most intricate components and piece parts with the finest of tolerances and of a reliability on which the House of PRESTWARE has built its high reputation.

Prestware Ltd.

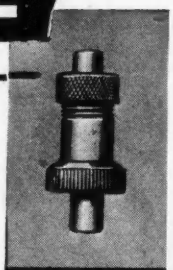
(T DIVISION) SOUTH DOWN WORKS, KINGSTON RD., RAYNES PARK, S.W.20

Telephone: LIBerty 3421

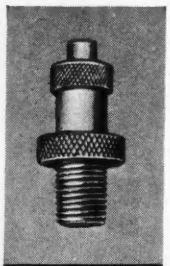


MINIATURE

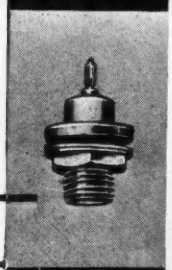
CO-AXIAL SEALED PLUGS AND SOCKETS



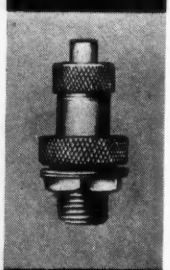
732560
732557



732561
732558



732564
732563



732562
732559

TYPE APPROVED—
COMPLYING WITH R.C.S. 322
PRESSURE SEALED AND
100% TESTED
USED WITH UNIRADIO 32
OR 43 CABLE

A.I.D. & A.R.B — APPROVED

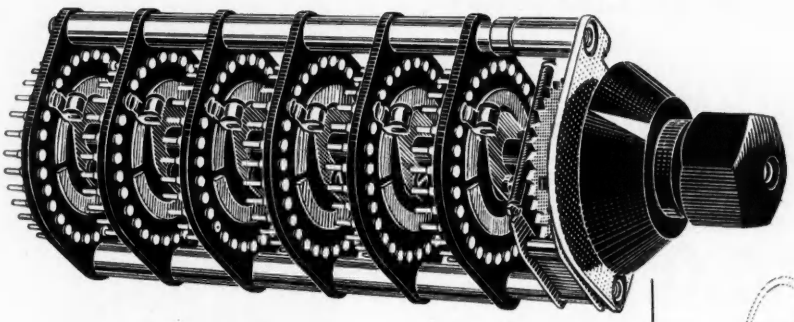
EXNING RD., NEWMARKET

POWER CONTROLS
LIMITED

PHONE: NEW 3181/2/3

PAINTON

By Appointment to the Professional Engineer



PAINTON WINKLER SWITCH

VOLTAGE RATING : 250 volts A.C. / D.C. (maximum).

CURRENT RATING : 0.5 amp. (maximum).

Switching up to 29 positions (single-pole) per bank, or up to 30 positions per bank for 360° rotation.

Painton Winkler Switches can be supplied for either 'Make-before-Break' or 'Break-before-Make' operation.

Each switch has an adjustable stop device, by which the switch can be set to the number of positions required.

SINGLE, DOUBLE, THREE-POLE or FOUR-POLE.

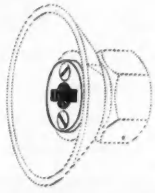
1-6 BANKS OPERATED FROM A COMMON SHAFT.

The distinctive Painton knob type K21, with the 'adjustable skirt' feature has been specially designed to operate Painton Winkler Switches.

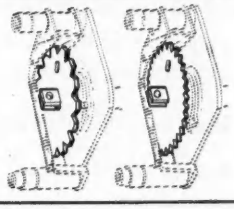
AVERAGE CONTACT RESISTANCE : BETTER THAN 0.004 OHMS.

PAINTON
Northampton England

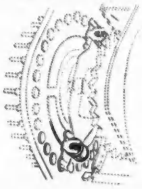
The white pointer can easily be lined up with dial markings. The friction-plate can be loosened by two screws, allowing the skirt of the knob to rotate.



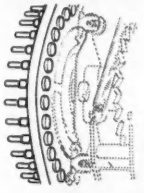
'Break-before-Make' or 'Make-before-Break' operation.



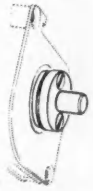
The 'direct-link' wiper provides a low capacity and inductance connection between the individual contact studs and the collector ring, and because the wiper is freely pivoted a constant and even contact pressure is obtained.



The contact studs are moulded into the nylon-filled phenolic resin panel, and though normally Silver-plated, can be specially Rhodium-plated if required. The rigid stems of the contact studs are tinned to facilitate soldering connections.

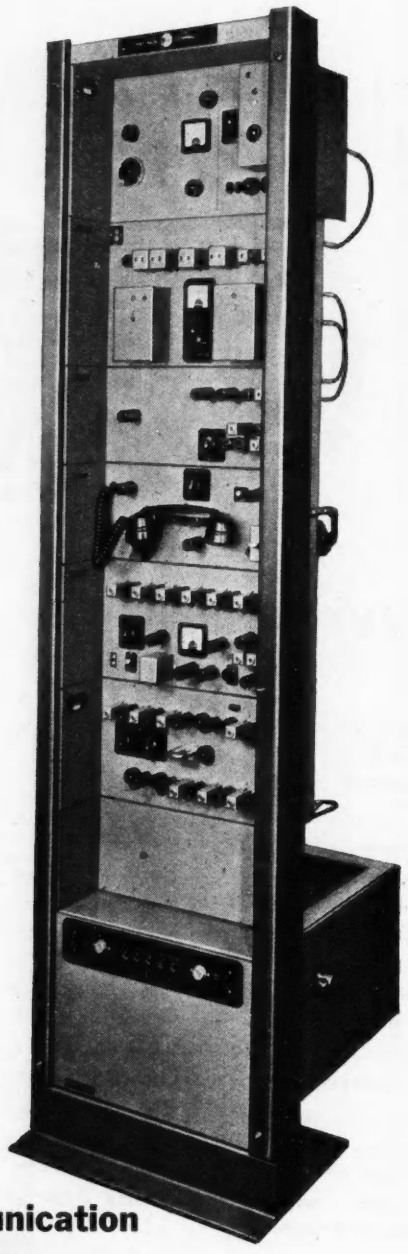


The number of operating positions can be altered. Two stop plates can be adjusted by loosening a friction-plate clamped by two screws.



Marconi VHF Multi-Channel Equipment

TYPE HM 181



Multi-channel radio links are not only recognised economic alternatives to line and cable routes wherever the latter are costly because of intensive urban development or the wild nature of the terrain; they are frequently preferable in their own right. The type HM 181 equipment has been designed for comparatively simple schemes using two terminals working point-to-point or with a limited number of repeaters. It operates in the frequency range 150-200 M/cs, employs frequency modulation and gives high performance with low distortion.

It provides the following facilities:—

- 8, 16 or 24 channels
- Repeaters with easy channel dropping facilities
- Unattended operation
- Engineers' order wire
- Ease of access for maintenance

Over 80 countries now have Marconi equipped telegraph and communication systems. Many of these are still giving trouble free service after more than twenty years in operation

Lifeline of communication

MARCONI

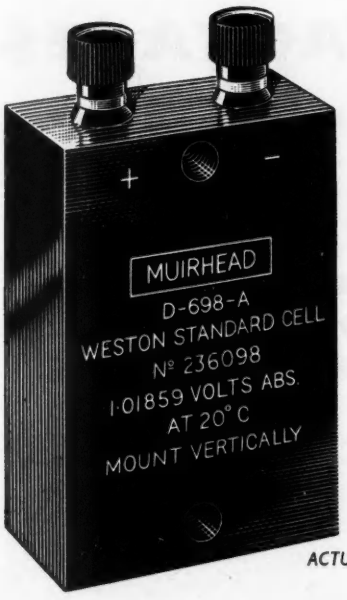
COMPLETE COMMUNICATION SYSTEMS

Surveyed, planned, installed, maintained

MARCONI'S WIRELESS TELEGRAPH CO., LTD., CHELMSFORD, ESSEX

Partners in progress with The **'ENGLISH ELECTRIC'** *Company Ltd.*

LC 7



ACTUAL SIZE

A New Standard Cell by MUIRHEAD

£3.0.0

Post free in U.K.

D-698 WESTON STANDARD CELL

This new cell combines the robustness and small size of our D-550 Miniature Standard Cell with a high capacity previously only obtainable in larger and more expensive types such as our D-402.

Whether you require a standard of E.M.F. for an industrial application or for laboratory use, this new cell will meet your needs and give many years of reliable service.

SPECIFICATION

E.M.F.	1.01859V + 110μV − 90μV at 20°C.
Temperature coefficient	−0.00004 per °C.
Discharge rate	Up to 20μA for short periods
Internal resistance	600 ohms
Overall dimensions	$1\frac{15}{16}$" x 1" x $3\frac{3}{16}$"
Weight	4 oz.

Our D-550-A and D-402 Weston Standard Cells are still available

MUIRHEAD

PRECISION ELECTRICAL INSTRUMENTS

WRITE UNDER YOUR BUSINESS LETTERHEAD FOR PUBLICATION 5716

138

MUIRHEAD & CO. LIMITED · BECKENHAM · KENT · ENGLAND

4 UNIQUE ADVANTAGES OF RELAY OPERATION WITH THE NEW Z900T

COLD CATHODE TRIGGER TUBE

STANDBY LOSSES — ZERO

HEATER FAILURES — NIL

OPERATION — INSTANTANEOUS

A.C. OR D.C. ANODE SUPPLY

In all applications where a suitable trigger voltage is available, outstanding advantages are to be gained with the new Mullard Z900T cold cathode tube. This latest addition to the Mullard range of trigger tubes is a general purpose type equivalent to the American 5823.

As no heater is used in the Z900T, it is well suited for equipments requiring a large number of tubes, such as computors, where heat dissipation during standby is frequently a major problem.

The absence of a heater also means the elimination of a possible source of failure—the Z900T is extremely reliable and is recommended for safety devices.

Where operation is non-continuous, the Z900T remains ready for instantaneous action—warming-up time does not have to be considered with this cold cathode tube.

The Z900T may be operated from a d.c. supply of up to 200V. Alternatively an a.c. voltage of 115V r.m.s. may be used for automatic tube extinction.

Abridged Data		
Max. Average Cathode Current ... (Max. Averaging Time 15 secs.)	... (mA)	25
Max. Peak Cathode Current ...	... (mA)	100
Max. Operating Anode Voltage ...	... (V)	200
Anode-Cathode Burning Voltage at 25 mA	(V)	62
Trigger Firing Voltage	(V)	73 to 105
Typical Critical Ignition Current at V_a = 140 V	(μA)	50
Min. Trigger-Cathode Transfer Current at V_a = 175 V	(μA)	160

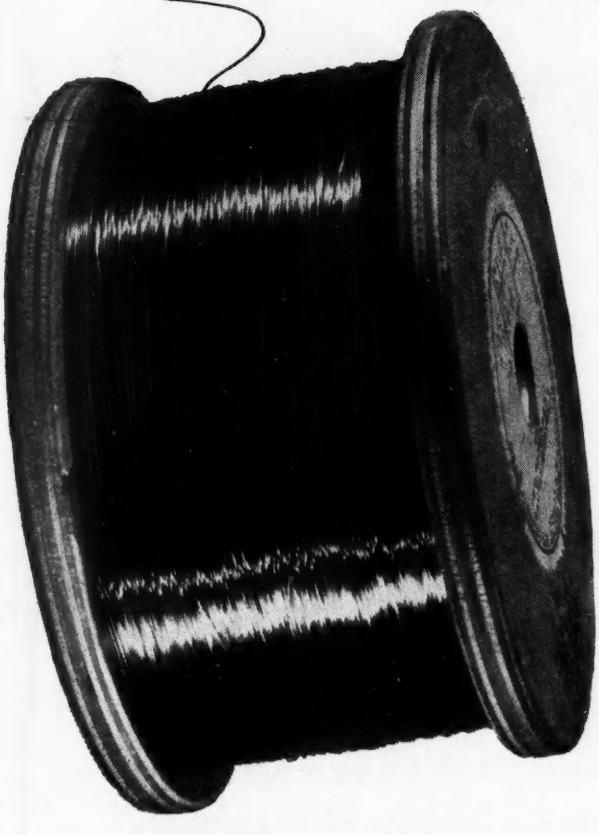
Full information is readily obtainable from the address below.

Mullard

MULLARD LTD., COMMUNICATIONS & INDUSTRIAL VALVE DEPT., CENTURY HOUSE, SHAFTESBURY AVE., W.C.2

MVT 165

THE NEW
SILICONE
ENAMELLED WINDING WIRE



SEVERAL YEARS' RESEARCH lies behind the introduction of the new silicone wire enamel MS 1360. It has the toughness, flexibility, solvent resistance and adhesion expected of modern wire enamels and in addition has *outstanding heat stability.*

Accelerated life testing of electric motors wound with MS 1360-enamelled wire and insulated with silicone-bonded (Class H) components indicates that such motors, when operated at an average copper temperature between 160°C and 180°C, have a life comparable to Class A insulated motors operated within their normal temperature limits.

MS 1360-enamelled wire is available in fine and medium coverings, as defined in B.S. 1844. *Ask for Silicone Notes* C 18—*Silicone enamelled wire.*

Information about suppliers of wire and silicone insulating components is contained in Silicone Notes C 19, obtainable on request from:

MIDLAND SILICONES LTD.

An associate company of ALBRIGHT & WILSON Ltd.

first *in British Silicones*

MS 19 UPPER BROOK STREET • LONDON • W.1 • TELEPHONE: GROSVENOR 4551

RELAYS

announcing the

2400 RELAY

A Relay of noteworthy dimensions, designed in size and performance to suit present day electronic equipment. The new 2400 Relay is available with twin light duty or single heavy duty contacts.

When fitted with a 10,000 ohm coil, the pull-in is approximately 4 milli-amperes; contact pressure and clearance have not been sacrificed to achieve this sensitivity.

DIMENSIONS: Above chassis 2½" high x 1" wide x 1⅝" deep.

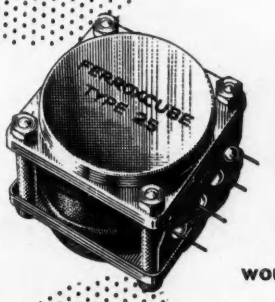
WEIGHT: 4½ ounces.

MAGNETIC DEVICES LIMITED

MAGNETIC DEVICES LTD

NEWMARKET

MD6



High Q inductance coils

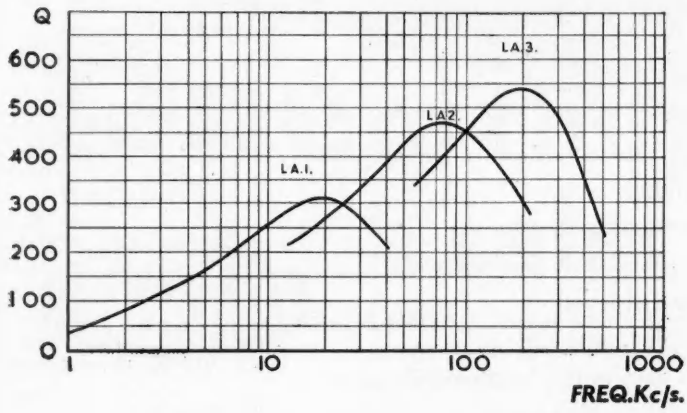
wound on Ferroxcube cores

DESIGNERS of compact and efficient tuned circuits and wave filters are making ever-increasing use of Mullard high Q inductance coils.

Based on Ferroxcube, the world's most advanced magnetic core material, these coils combine small size with an inductance of up to 30 henries over a wide frequency range. Furthermore, their convenient shape and self screening properties facilitate either individual mounting or stacking.

Full details of these and other high grade components now available from Mullard will be gladly supplied on request.

TYPICAL Q VALUES



Special Features

Small size

Low hysteresis loss factor

High value of inductance

Low self capacitance

Controllable air gap facilitating inductance adjustment

Self screening

Controlled temperature coefficient

Operation over a wide frequency range

Easily mounted

Mullard

'Ticonal' permanent magnets, 'Magnadur' ceramic magnets, Ferroxcube magnetic cores.

MULLARD LIMITED · COMPONENT DIVISION · CENTURY HOUSE · SHAFTESBURY AVENUE · LONDON · W.C.2
(MM450)

AC sorensen VOLTAGE REGULATOR

— a precision instrument of outstanding performance

MODEL L.T.-1000-2S

- Reliability
- Exceptional accuracy
- Not affected by frequency
- Low distortion
- Fast response time
- No load to full load performance
- Excellent finish and fine workmanship throughout

Specification

RATING	1 KVA
INPUT VOLTAGE	190-260
INPUT FREQUENCY	50 c/s ±10%
OUTPUT VOLTAGE	220-240 (adjustable)
REGULATION ACCURACY	±0.1% nom.
RECOVERY TIME	0.1 secs.
HARMONIC DISTORTION	3% nom.
P.F. RANGE	Unity to 0.7
LOAD RANGE	No load to full load

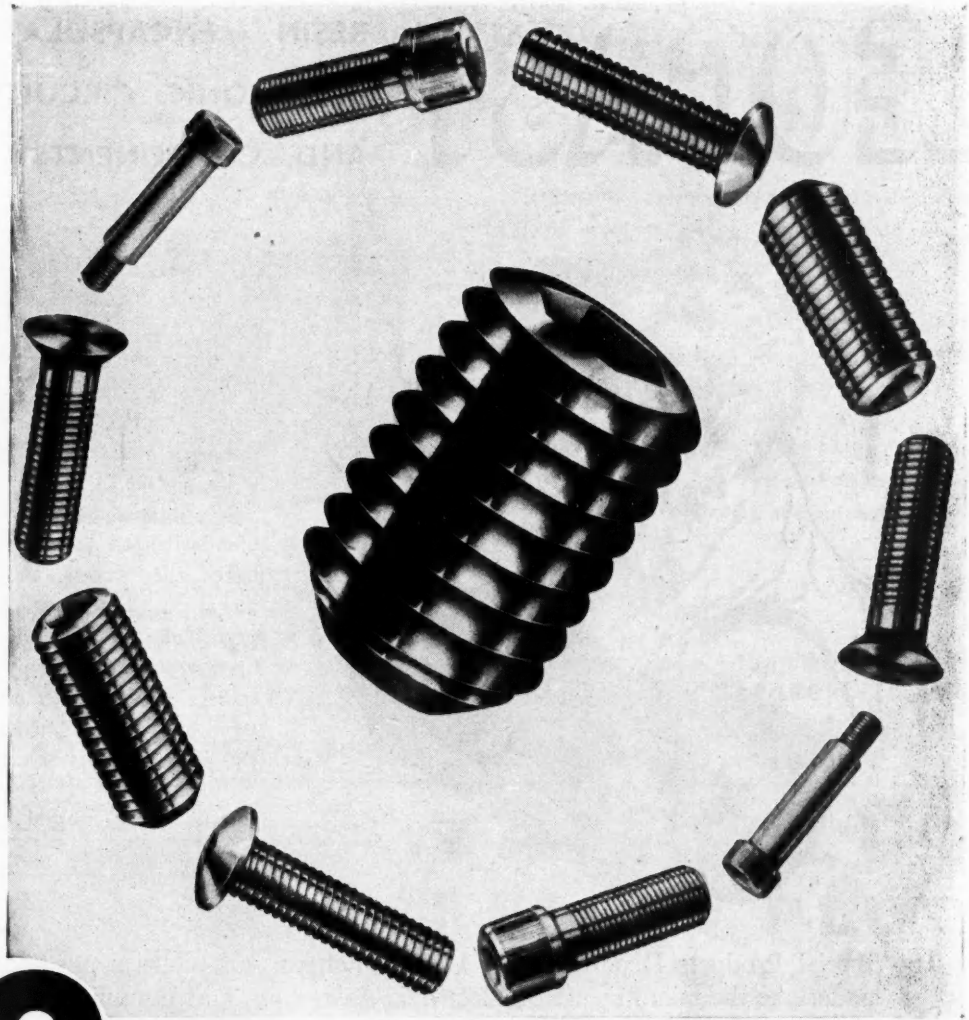
Manufactured under licence by:—

J. LANGHAM THOMPSON LTD.

BUSHEY HEATH · HERTS.

Telephone: BUShey Heath 2411 · Grams and Cables: "Tommy Watford"

JLT GROUP



One of the gems in a select circle

UNBRAKO

UNBRAKO set screws—gems of precision and hardness—are relied upon for a thousand and one applications in every branch of engineering. Unbrako screws are made in all standard sizes and threads, and those particularly applicable to the Wireless and Electrical Industries—from 6 BA Set screws and 8 BA Cap screws.

Available from UNBRAKO distributors throughout the world.

UNBRAKO SOCKET SCREW CO LTD
COVENTRY ENGLAND

LEOCAST

RESIN ENCAPSULATED ELECTRONIC CIRCUITS AND COMPONENTS.

Leocasting is the specialised process of CASTING OR MOULDING IN RESIN of components or sub-circuits. It embraces such terms as 'Potted Circuits,' 'Moulded Circuits' and 'Resin Cast' or 'Resin Encapsulated' Circuits.

Lion Switchgear Ltd. have perfected the process, and will carry out Leocasting on a prototype or production basis using resins specified by customers or will select one of their own special 'mixes' for the particular application.

Ask for the LEOCAST leaflet for fuller details.

The Special Products Department of Lion Switchgear Ltd. is in a position to undertake the manufacture of Electronic Assemblies and Equipments. Prototypes, large batches or short pre-production runs of equipment can be produced to specification. This service includes the fabrication of the metalwork, electro-plating, spraying and finishing as well as the assembly, wiring and testing. **Ask for the Special Products Leaflet.**

★ EXPORT ENQUIRIES INVITED ★

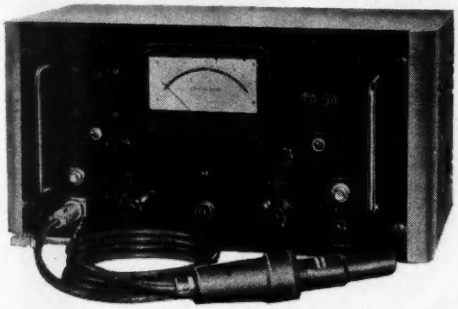
Details are available from :—

LEOCAST ELECTRONIC DEVELOPMENTS

DIVISION OF

LION SWITCHGEAR LIMITED

LION WORKS, HANWORTH TRADING ESTATE
HAMPTON ROAD, FELTHAM, MIDDLESEX
Telephone : FELtham 3567 & 2922



THE 'I.D.L.'

RATEMETER

Type 550

Designed for accurate rate measurements the instrument forms a self-contained unit for educational purposes, general investigations and laboratory monitoring.

Complete with probe, containing cathode follower, for alpha, beta and gamma ray measurements, operated from built-in variable E.H.T. supply.

Variable count/rate and time constant settings. Fitted loudspeaker in addition to first grade mirror/scale meter. Recording and pulse monitoring facilities.

Full particulars from :

ISOTOPE DEVELOPMENTS LTD.

120 · MOORGATE
LONDON · E.C.2.
Telephone:
METropolitan 9641 (5 lines)

Midland Agent: **HAWNT & CO. LTD.,**
59, Moor Street, Birmingham, 4. Tel.: Central 6871.

Northern Agent: **A. M. LOCK & CO. LTD.,**
Crompton Street, Chadderton, Oldham, Lancs. Tel.: Main 6744.

Scottish Agent: **A. R. BOLTON & CO.,**
72, Haymarket Terrace, Edinburgh, 12. Tel.: Edinburgh 62446.

TANTALUM
REPAIR PLUGS

Photograph by courtesy of Enamelled Metal Products Ltd.

Tantalum Repair Plugs for repairing leaks in enamel or glass lined tanks are manufactured by Murex Ltd. and can be supplied to suit customers' requirements.

MUREX LTD. *(Powder Metallurgy Division)*
RAINHAM · ESSEX · *Rainham, Essex 3322*
London Sales Office:
CENTRAL HOUSE, UPPER WOBURN PLACE, W.C.1

NARITE
-acclaimed

THE GREATEST **ADVANCE** IN DIE-METAL TECHNIQUE

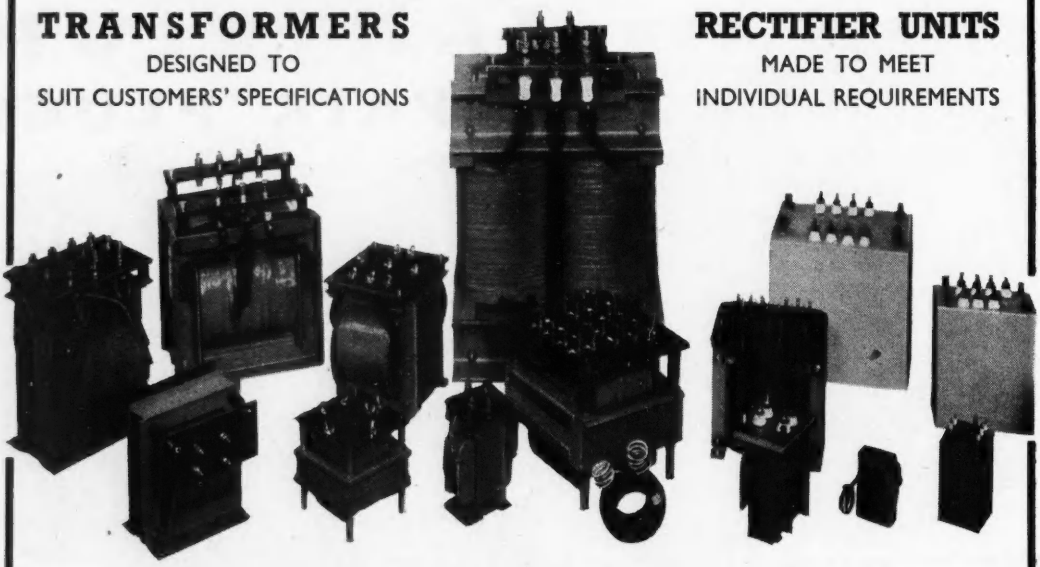
HEAT-TREATMENT
SCORE MARKS
SCUFFING
GALLING
ELIMINATED

N.C. ASHTON LTD. ST. ANDREW'S ROAD HUDDERSFIELD ENGLAND HUDDERSFIELD 6263/4

CW 2575

TRANSFORMERS
DESIGNED TO
SUIT CUSTOMERS' SPECIFICATIONS

RECTIFIER UNITS
MADE TO MEET
INDIVIDUAL REQUIREMENTS



Write for leaflet T.I.

AUSTIN WALTERS & SON LTD. AYRES ROAD OLD TRAFFORD MANCHESTER, 16 PHONE-TRAFFORD PARK-1827 (2 lines)

Z-g DIAGRAPH: a NEW instrument

FOR

plotting impedance

IN RADIO FREQUENCY CIRCUITS

Eliminates lengthy and cumbersome calculations

All measurements read direct from interchangeable charts

Type ZDU for 30 — 300 Mc/s.

Type ZDD for 300—2,400 Mc/s.

A UNIQUE DEVICE specially developed for rapid, accurate impedance and admittance measurements by Germany's leading instrument-maker, the Z-g Diagraph indicates results by the light spot projected on to a Smith or similar chart. An entire broadband characteristic is presented visually in a few minutes.
There is direct indication of the transmission characteristic of a four-terminal network or the phase angle between two voltages of unequal amplitude at the same frequency.
Charts available for measurement of Reflection Coefficient, Resistance, Reactance or Magnitude and Phase Angle of an unknown impedance. Usable without recalibration or reconnection.
Write for details of this and other new instruments.

Sole Agents for U.K. for Rohde & Schwarz, Munich:—

AVELEY ELECTRIC LTD.

44 TOTTENHAM COURT ROAD, LONDON, W.1

Telephone : LANgham 7097. *Telegrams :* AERSALE, WESDO, LONDON.

85/1

ELECTROPHYSIOLOGICAL TECHNIQUE

By C. J. DICKINSON, B.A., B.Sc. (Magdalen College, Oxford)

Price 12/6

(Postage 6d.)

The author describes the use of electronic methods as applied to research in Neurophysiology.

Chapters are devoted to amplifying, recording and stimulating techniques used in Physiology and Medicine (e.g., electro-cardiography, electro-encephalography, etc.).

Order your copy through your Bookseller or direct from :—

Electronic Engineering

28 ESSEX STREET, STRAND, LONDON, W.C.2.

7 ESSENTIALS for a PERFECT RESISTOR*

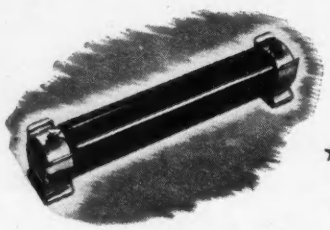
1 **Perfectly even winding before and after firing.**
Turns could easily become bunched during firing processes due to the surface tension of the molten enamel. Bunched windings would cause hotspots, burn-outs and breakdown of inter-turn insulation.

2 **Moisture proof enamel and tube at all temperatures.**
Cracks or pores in the tube or enamel would allow moisture to penetrate and cause corrosion, changes in resistance value and open circuits.

3 **Enamel and tube must be good insulators at high temperatures of 300 to 400°C.**
If the insulation resistance of the enamel or tube were to drop at high temperatures it would be necessary to impose a limit to the voltage which could be applied. This would reduce the permissible loading of units of high unit value, and increase the size or number of units required for a given duty.

4 **Welded internal connections.**
Imperfect internal connections would cause intermittent changes in resistance value and faults difficult to locate.

5 **Enamel, tube and winding must be thoroughly annealed during firing.**
Internal stresses in materials would be revealed as cracks in the surface of the enamel, cracked tubes or open circuits due to mechanical fracture of the fine wires.



6 **Matched expansion coefficients of tube, wire and enamel.**
The big operating temperature range of vitreous resistors would cause cracks in the ceramic materials or breakage of winding if stresses were set up due to unbalanced expansion coefficients.

7 **The vitreous enamel must be chemically inert at temperatures up to 1,000°C.**
Enamels which have a chemical action on the wire at high temperatures would cause eventual open circuits.

★***These seven features are incorporated in all BERCO vitreous enamelled resistors which are manufactured in a wide range of sizes and mountings***

BERCO

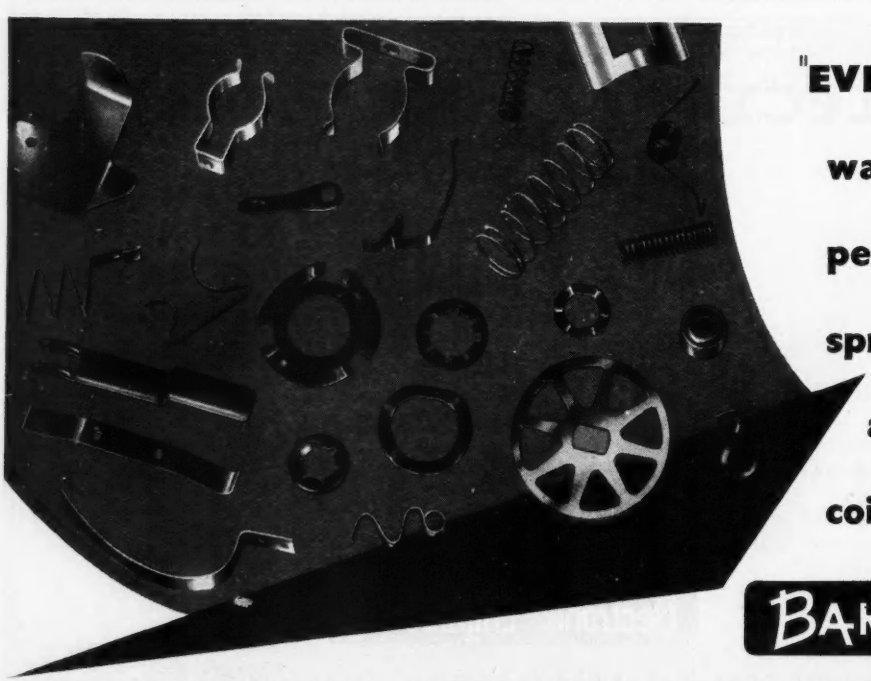
Write for Booklet L.611

VITREOUS ENAMELLED RESISTORS

THE BRITISH ELECTRIC RESISTANCE CO. LTD.

QUEENSWAY, PONDERS END, MDX. Tel: Howard 1492. Grams: Vitrohm, Enfield.

BR2111-BXH.



"EVERLOCK"

washers

pen steel

springs

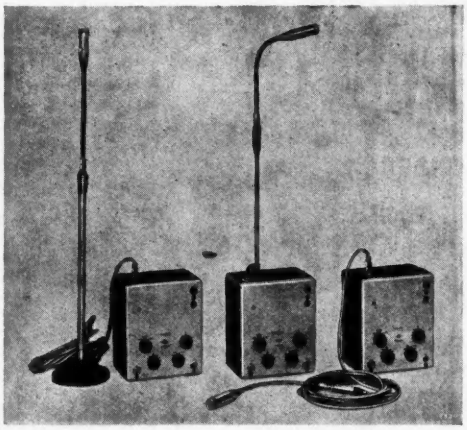
and

coils by

BAK-FIN

BAKER & FINNEMORE LTD · 197-207 NEWHALL STREET · BIRMINGHAM · 3

TELEPHONE: CENTRAL 2838



CONDENSER MICROPHONE Type 4111
MICROPHONE AMPLIFIER Type 2601

two precision instruments for acoustic measurements such as

NOISE LEVEL MEASUREMENTS
MEASUREMENTS OF REVERBERATION TIME
MEASUREMENTS OF AIRBORNE SOUND
RECORDING OF FREQUENCY CHARACTERISTICS OF LOUDSPEAKERS, MICROPHONES ETC.

The Condenser Microphone, a small rugged standard microphone, features among others a linear frequency response within ± 2 db from 80—16.000 c.s. Sensitivity of approx. 2 mV per μbar unaffected by humidity change and a very low temperature coefficient, whereas the microphone amplifier is specially designed as a high gain low distortion unit for amplification of a low level audio signal, with a maximum amplification of 80 db. Three phon weighting networks, conform to the ASA standard, are incorporated.

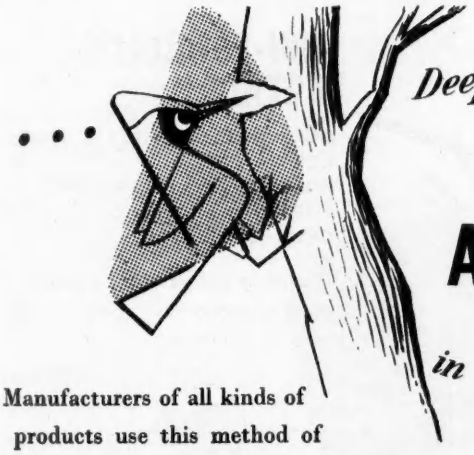
For full details please write to

ROCKE INTERNATIONAL LTD.
59 Union Street, London, S. E. 1.
Tel.: HOP 4567

B K

Brüel & Kjær

Adr. Nærum, Denmark . Telephone: Nærum 500 . Cable: Brukja, Copenhagen

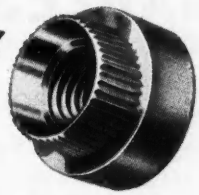


Deep tapped Holes

PRECISION
PATENT SERRATED
Anchor RIVET Bushes

in thin Sheet Metal

Manufacturers of all kinds of products use this method of fastening to metal sheets and panels. Note the serrations on the finely tapered shank — these cut their way into the sheet and prevent the bush from rotating in the panel.



Ask for Illustrated Leaflet 155

THE PRECISION SCREW & MFG. Co Ltd UNION STREET • WILLENHALL • STAFFS.

Telephone: WILLENHALL 621 & 622

AIR-DAMPED

ANTI-VIBRATION MOUNTS

of exceptional performance:

FOR THE PROTECTION OF AIRBORNE EQUIPMENT

- Superior vibration isolation.
- Improved shock absorption.
- Low permanent set and drift.
- Operation over wide temperature range.
- Minimum side sway.
- Wide load range with uniform performance.

Air-damped BARRYMOUNTS have been specially developed to provide assured protection for sensitive equipment against shock and vibration. An outstanding feature is their remarkably uniform performance over the full range of rated load variation.

Over 1,000,000 BARRYMOUNTS go into use *every year* for the protection of every type of air-borne equipment, from the lightest and most delicate instruments and electronic devices to apparatus up to 140 lbs. weight.

There are also BARRYMOUNTS available for specialised vehicle-borne and ship-borne equipment applications.

Air - damped BARRYMOUNTS are supplied in a wide range of sizes for Rated Loads of from 0.1 to 35 lbs.

MINIATURIZED BARRYMOUNTS ARE USED IN THE BRISTOL "BRITANNIA"

Made in England under license from the Barry Corporation of U.S.A.

Write for technical bulletins:

CEMENTATION (MUFFELITE) LTD.,

39 VICTORIA ST., LONDON, S.W.1 (ABBey 5726)

CB1

BARRYMOUNTS

Make a note

TO SEE

CHARLES CLIFFORD

ABOUT *Metal*

NON-FERROUS METALS

COLD ROLLED SHEET & STRIP
RODS & BARS
WIRE AND DRAWN STRIP
TUBES
CHILL CAST BARS

PHOSPHOR BRONZE, GUNMETAL
BRASS & COPPER
GILDING METAL, ETC.

Chas. Clifford Birmingham

CHARLES CLIFFORD LIMITED

Dog Pool Mills, Birmingham 30
and
Fazeley St. Mills, Birmingham 5

SPECIALISTS IN THE PRODUCTION OF WROUGHT HIGH TENSILE ALLOYS

M-W.103

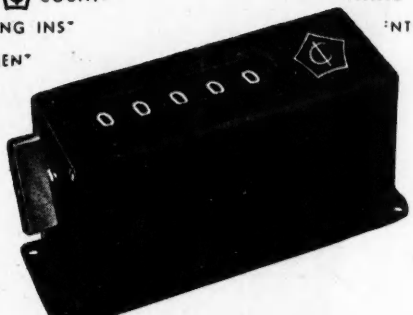
Complies with British Standards 972 · 668 · 1137 Fabric base to R C S 1000 specification

Wherever an efficient combination of mechanical strength and sound insulating properties is required, 'Pirtoid' provides the modern answer.
Superior under severe operating conditions, resistant to shock loading, easily punched to yield clean, sound blanks, amenable to effective drilling without delamination, 'Pirtoid'—for Terminal Supports and Bases, Brush Holders, Bobbins and Coil Formers, Panels, Insulating Bushes and Handles—is the material of the moment.

Just between ourselves . . . and electricity you need PIRTOID *insulated laminate*

PIRTOID IS A SYNTHETIC RESIN BONDED LAMINATED FABRIC OR PAPER BASED SHEET TO APPROVED A.I.D. SPECIFICATION AND CAN BE MACHINED, FORMED OR MOULDED TO ANY SHAPE

Manufactured solely by H. CLARKE & CO (MANCHESTER) LTD ATLAS WORKS PATRICROFT MANCHESTER



Illustrated is our Proud Mounting Electro-Magnetic Counter with five figures, details of this and other models are given in our leaflet EM.

COUNTING INSTRUMENTS LTD.
5, ELSTREE WAY, BOREHAM WOOD, HERTFORDSHIRE
Telephone: ELSTREE 1382-3-4 *Cables:* COUNTHOR BOREHAMWOOD

NEW *MEDIUM-SPEED* PLOTTING TABLE

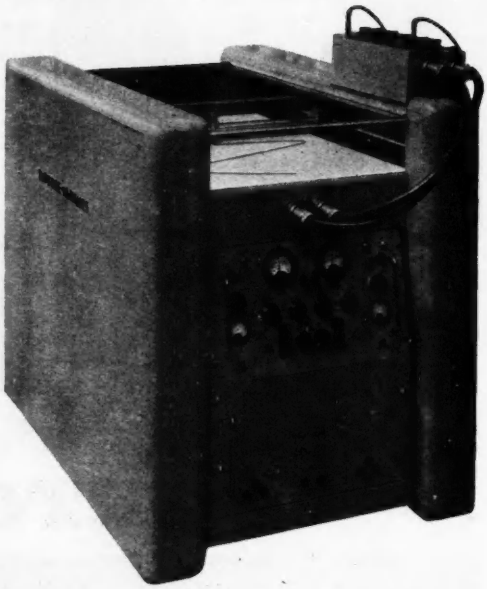
A mains-operated general purpose instrument for plotting the relationship between any 2 variables at rightangles (X, Y co-ordinates).

It is **self-contained** and rapidly records directly on **30 in.** × **18 in.** paper.

Meticulous care has been given to Accuracy, Ease of Operation and Setting up.

●

For very high speeds, the Dobbie McInnes 'Ferranti' High-Speed Recorder is recommended.

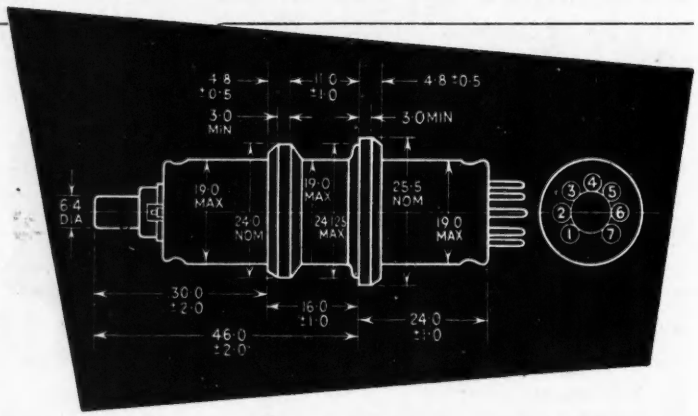


DOBBIE McINNES LTD. BROOMLOAN ROAD, GLASGOW, SCOTLAND.

A NEW E.M.I. CENTIMETRIC VALVE

10 cms.
THREE BAND
KLYSTRON
2600-3700 Mc/s.

TYPE RK6112



This is a low voltage, reflex velocity modulated valve for use as a local oscillator in the 10 centimetre ("S") Band. It is of the plug-in type, with disc seals for resonator connection, and is indirectly heated.

TYPE RK6112 SPECIFICATION

Power Output	100 mW minimum	Reflector Current	4 micro-amps max.
Frequency Range (with suitable cavity)	2600 — 3700 Mc/s	Cathode Shield Volts	0
Resonator Voltage *	+ 250 Volts	Heater Volts	6·3 volts
Resonator Current	18 — 34 mA	Heater Current	0·7 max.
Reflector Voltage * Range	−55 to −350 volts		

* Measured with respect to Cathode

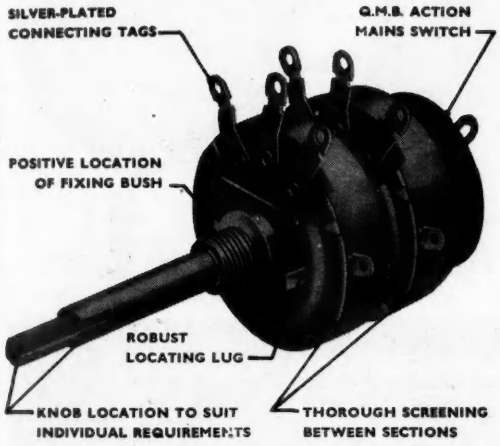
Write for particulars to—

E.M.I. FACTORIES LTD., HAYES, MIDDLESEX, ENGLAND

New EGEN

DUAL POTENTIOMETERS

● *with concentric operating spindles*


SILVER-PLATED CONNECTING TAGS
Q.M.B. ACTION MAINS SWITCH
POSITIVE LOCATION OF FIXING BUSH
ROBUST LOCATING LUG
KNOB LOCATION TO SUIT INDIVIDUAL REQUIREMENTS
THOROUGH SCREENING BETWEEN SECTIONS

Designed primarily for television and electronics applications these new Egen Dual Potentiometers incorporate all the outstanding design features — multiple contact rotors, smooth easy movement and freedom from wear and noise — that have made the well-known Egen Type 102 Carbon Potentiometers so dependable in service.

They are thoroughly screened between sections and a convenient soldering tag for earthing screened connections, etc. is provided on each metal case. Switch and potentiometer soldering tags are of high grade brass heavily silver plated for easy soldering; they are positively located and withstand soldering heat and bending without loss of rigidity.

Control spindles can be supplied to suit customers' requirements.

The wide range of EGEN controls includes: Carbon Potentiometers Type 102 · Pre-set Resistors Type 104 · Miniature Carbon Potentiometers Type 105 and 115 · Sub-miniature Volume Controls Type 111, 123 and 125 · T.V. aerial plug and socket · Pre-set potentiometers Type 126/127.

EGEN ELECTRIC LTD., Charfleet Industrial Estate, Canvey Island, Essex • Phone : CANVEY ISLAND 691/2

"Finger-tip flame control"

said a silversmith, "Pleasant to handle, very sensitive controls."

He was one of the many users of our Flamemaster Mark II and the three comments he made probably sum up the main reasons for the Flamemaster's immense popularity.

Also:

It burns coal-gas or bottled-gases of the butane type with equal efficiency . . .

The air or oxygen pressure needed is comparatively low . . .

All the different flame-units are easily interchangeable . . .

It won't splutter or give you an unstable flame . . .

It won't leak, even on high pressures . . .

It won't raise your running-costs, (our economiser-trigger sees to that) . . .

But it *will* bring speedy and reliably controlled heating right to the spot where you need it . . .

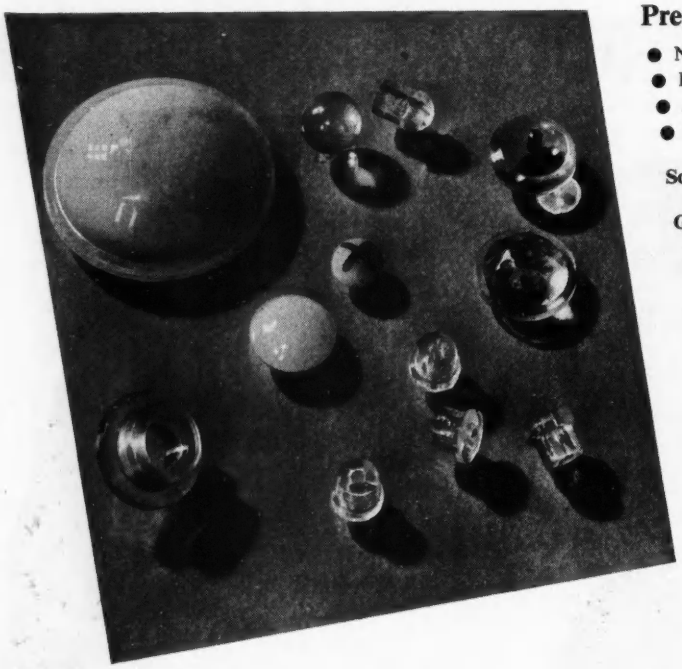
remember the name

FLAMEMASTER MARK II

Write for full details to :—

STONE CHANCE LIMITED

DEPT. F.28, LIGHTHOUSE WORKS, SMETHWICK 40, BIRMINGHAM.
TELEPHONE : BROADWELL 2651.
LONDON OFFICE: 28 ST. JAMES'S SQUARE, S.W.1. TEL: WHITEHALL 6002.



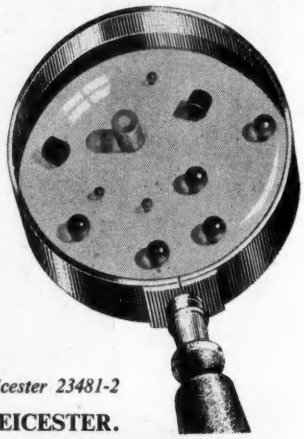
Precision Ground Glass Balls

- Non-conducting.
- High surface polish.
- Available from 0.070″ diam. upwards.
- Sphericity to 0.0003″ on large and 0.0005″ on small size balls.

Solid Glass Beads (Ballotini)
Range 0.10 mm. to 10 mm. diam.

Glass Beads for fusing wires into "Headers".

Indicator Glasses for electrical equipment from ¼″ to 2″ diameter.

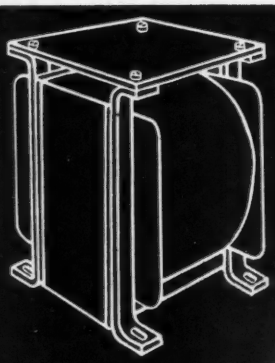


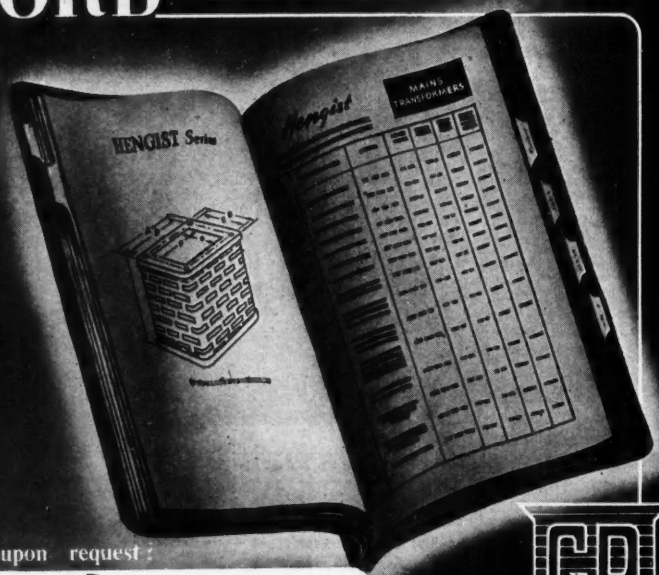
EGC *Specialists in small glass mouldings* *Telephone : Leicester 23481-2*

THE ENGLISH GLASS CO. LTD., EMPIRE RD., LEICESTER.

SOMERFORD TRANSFORMERS AND CHOKES

A range of 360 standard types available for "off the shelf" delivery in several different mounting styles including both open and hermetically sealed "C" cores.





Fully descriptive Catalogue upon request :

GARDNERS RADIO Ltd

GR

SOMERFORD CHRISTCHURCH HANTS *Tel : 1024/5*

Garrard for preference

There is a preference for Garrard equipped radiograms.

A closer look at the Garrard RC.80m, the new RC.90,110 or 111, and the reason for such preference becomes obvious.

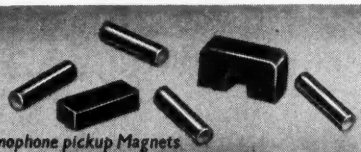
The buying public recognises superior sound reproduction, and knows that the Garrard autochange and pickup are kindest to both standard and microgroove records.

The demand for Garrard three speed, automatic record changers and single record players very much exceeds the supply but you know from experience, whenever possible, to install and to stock

Garrard
record playing units

GARRARD SWINDON

Focussing Magnet ALCOMAX IV



Gramophone pickup Magnets ALCOMAX III

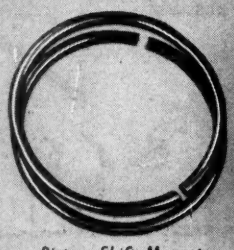
ALCOMAX II Loud Speaker Magnet

Permanent Magnets
for the
Radio & T.V. Industry

The very latest techniques in permanent magnet manufacture can effect real economies in your production and at the same time contribute further to efficient operation of your products. Consult our Technical Staff at an early stage of design to be certain that you are taking advantage of recent progress.

Made by the makers of 'Eclipse' Permanent Magnet Chucks

Send for literature:
Pub. PM108—Loud Speaker Magnets.
Pub. PM112—Permanent Magnets for Television Receivers.



Picture Shift Magnets in 6% Chromium Steel

Ion Trap Magnets ALNICO

Eclipse **PERMANENT MAGNETS**

JAMES NEILL & CO. (SHEFFIELD) LTD., SHEFFIELD, 11 ENGLAND

M3

THIS CONSOLE

IS IN OUR STANDARD RANGE

Reg. Des. No. 870016 and 7

It is robustly constructed and has
excellent ventilation.
Front panels of 10 S.W.G. steel
bolts to standard G.P.O. drillings
The top is of grey linette,
burn proof, formica.
Chassis runners and handles
can be supplied as an extra.
It is one of our range of standard
metal cabinets, cases, racks and
consoles.

SEND TO DEPT. C
for illustrated Catalogue
of our standard range.

IMHOFS 112-116 NEW OXFORD STREET, LONDON, W.C.I. MUSEUM 7878

NOT even a guardsman jumps to it like a spring made by Lewis of Redditch. We've spent over thirty years making them and every one has been designed to do a specific job as well as it could possibly be done. It's becoming a habit for progressive engineers to call us in at the design stage.

A-TENSION

THE LEWIS SPRING COMPANY LIMITED

RESILIENT WORKS, REDDITCH. **Tel: Redditch 720/1/2**

London Office: 321 High Holborn, W.C.I. *Tel: Holborn 7470 and 7479*

LEAVE IT TO
Lewis
OF REDDITCH
SPRINGS, SPRING CLIPS
PRESSWORK, WIRE FORMS
VOLUTE SPRINGS

Sensitive PENCIL TYPE RECORDING GALVANOMETERS

Range immediately available :—
0-40, 0-100, 0-250, 0-850, 0-3500 cycles/sec.

A plug-in type mirror galvanometer is now available to suit most types of photographic recorders. Primarily designed for the Aircraft Industry, their inherent stability makes them suitable for the recording of any physical dynamic quantity.

For information of our range of instruments for the measurement and recording of vibration, strains and pressures, write to . . . . . .

Length ..... 2·1 in.
Dia. Max....0·18 in.

NEW ELECTRONIC PRODUCTS LTD.

9 CAVENDISH STREET • LONDON W.1 • (WELbeck 1421-2)

HADDON

TRANSFORMERS LTD.

27-37 MASONS AVENUE,
WEALDSTONE, MIDDX.

Telephone :
HARROW 9022/3/4/5.

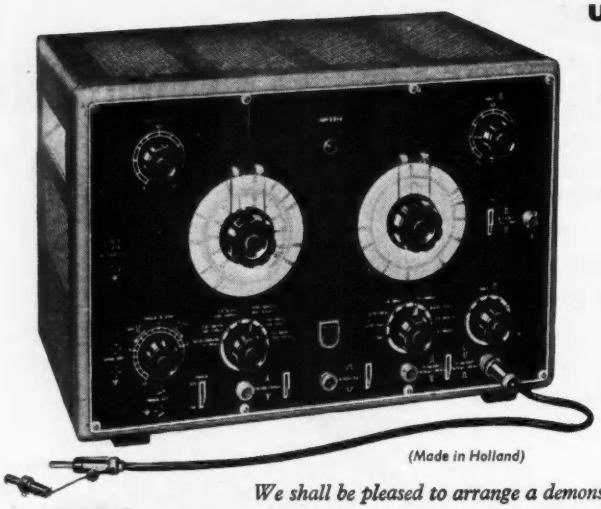
A.I.D. APPROVED

POWER and
AUDIO FREQUENCY
TRANSFORMERS

Open or Enclosed Types — For all climatic conditions

CONTRACTORS TO ALL GOVERNMENT DEPARTMENTS

PHILIPS PRESENT...



(Made in Holland)

UNIVERSAL PULSE GENERATOR
GM 2314

FEATURES:

1. Pulse frequency 15 c/s — 200 Kc/s in 6 ranges continuously variable. Accuracy within 10%.
2. Pulse width adjustable between 0.75μ sec and 40 m.sec in 7 ranges. Accuracy within 20%. Separate position for 50/50 pulse.
3. 50/50 pulse voltage output 10v max. with reversible polarity.
4. Adjustable pulse width voltage of 40v max in 5 steps and 0-1 v continuously variable. Rise time 0.1μ sec.
5. Narrow pulses of 0.25μ sec duration at 10v max also available with reversible polarity.
6. Sinusoidal voltage 15 c/s — 200 kc/s at 1v.r.m.s. can be obtained.
7. Suitable for external and internal synchronisation.

We shall be pleased to arrange a demonstration at your convenience

PHILIPS

PHILIPS ELECTRICAL LTD.

INDUSTRIAL DIVISION, CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2

ARC AND RESISTANCE WELDING PLANT AND ELECTRODES • HIGH FREQUENCY GENERATORS • ELECTRONIC MEASURING INSTRUMENTS • MAGNETIC FILTERS • BATTERY CHARGERS & RECTIFIERS • LAMPS & LIGHTING EQUIPMENT • X RAY EQUIPMENT
(PM10044)

Electricians & Instrument Mechanics WANTED

to spend FIFTEEN DAYS IN CAMP earning full pay and allowances plus a total of £9 TAX-FREE BOUNTY AND EFFICIENCY GRANT

You can spend fifteen days with your friends, earning full Regular Army pay and allowances. As a member of the Army Emergency Reserve (Cat. IIA) you have no other duties during the year. If a grave national emergency should arise you may be called up for service in the United Kingdom. You can be called out for overseas service only by Proclamation.

Volunteers are accepted from 18 years of age and engagement is for two, three, or four years. If you have served before in a non-commissioned rank there is every possibility of your filling an existing vacancy or of being promoted as soon as a vacancy occurs.

Lend your skill to Britain, doing the job you know best

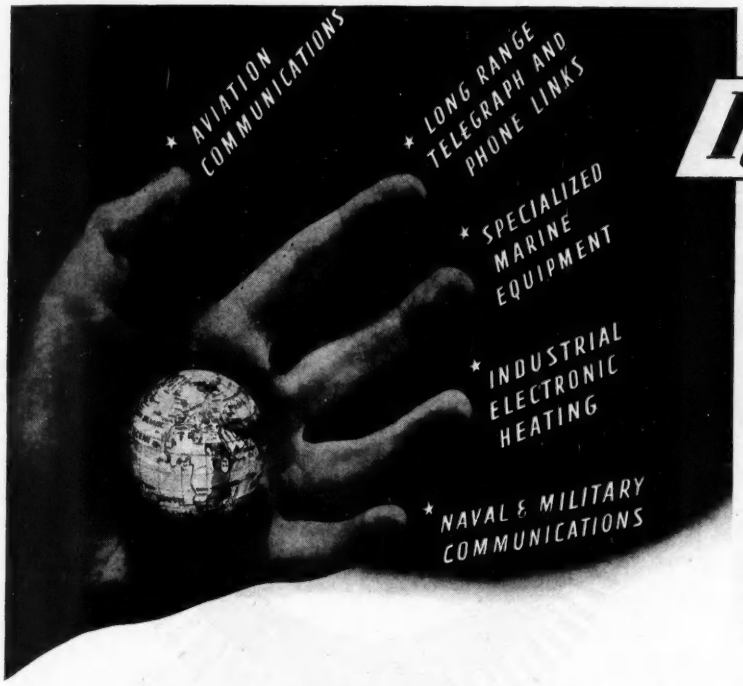
Army Emergency Reserve

Send this coupon now for details of how to join to:
O.C. HEADQUARTERS,
ARMY EMERGENCY RESERVE,
R.E.M.E., BROXHEAD HOUSE, BORDON.

NAME.....

ADDRESS .....

.....508


★ AVIATION COMMUNICATIONS
★ LONG RANGE TELEGRAPH AND PHONE LINKS
★ SPECIALIZED MARINE EQUIPMENT
★ INDUSTRIAL ELECTRONIC HEATING
★ NAVAL & MILITARY COMMUNICATIONS

Redifon

WORLD-WIDE SERVICES

Redifon offers these many services to those who are interested in Communications and Industry. If you have any problems in these fields we shall be pleased to discuss them with you.

REDIFON LTD., BROOMHILL ROAD, LONDON, S.W.18. Telephone: VANdyke 7281

A Manufacturing Company in the Rediffusion Group

SPECIAL SILVER CONTACTS FOR ELECTRONIC UNITS

Silver features largely in this metering Inductance shown by the courtesy of Messrs. PYE Telecommunications, Ltd., of Cambridge. Whilst the winding itself is of silver, the central contact at the right hand end and the twin rotary wheel travelling contacts are excellent examples of minute accuracy and finish typical of work from our Contacts Departments.

Special contacts in silver and the semi-precious metals to designers' requirements are everyday features of our production.

Our contact literature awaits your request.

The SHEFFIELD SMELTING Company Limited

SHEFFIELD · **LONDON** **BIRMINGHAM**

ROYDS MILL STREET, SHEFFIELD, 4. Tel: 26511

1, BERRY ST., CLERKENWELL, LONDON, E.C.1 Tel: CLE 3156

4, 5 & 6 WARSTONE LANE, BIRMINGHAM 18 Tel: Central 6893

IT is admitted that the present reception of the BBC's medium and long wave transmissions is most unsatisfactory in many parts of the country.

The BBC is proposing to remedy these conditions by erecting a chain of some 51 V.H.F. stations, and it is almost certain that F.M. will be the type of modulation chosen.

The principle of Frequency Modulation technique is discussed fully in :—

"Frequency Modulation"

By K. R. STURLEY, Ph.D., M.I.E.E.

Price 2/6 (postage 2d.)

The construction of a suitable receiver for the existing F.M. transmissions from Wrotham is described in :—

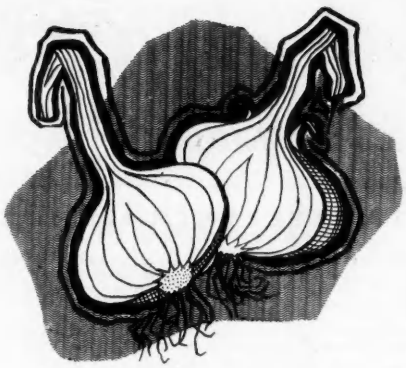
"A Home-Built Frequency Modulated Receiver"

By K. R. STURLEY, Ph.D., M.I.E.E.

Price 4/6 (postage 3d).

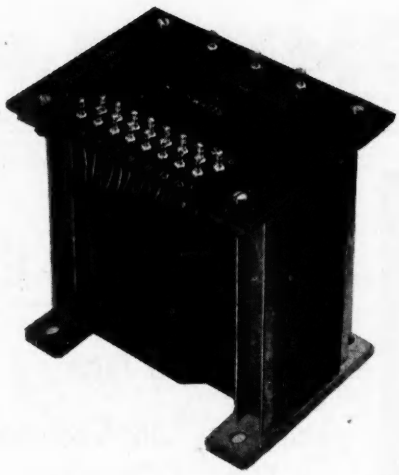
These and other monographs are obtainable from

28 ESSEX STREET, Electronic Engineering STRAND, LONDON, W.C.2



OUR CUSTOMERS KNOW THEIR ONIONS

and there are no tears !



No tears, because the wealth of experience behind each Savage Transformer satisfies even the most exacting customer.

SAVAGE TRANSFORMERS OF DEVIZES LIMITED

NURSTEED ROAD · DEVIZES · WILTS.

Telephone: DEVIZES 932

A. V. ROE & CO. LTD.,

Woodford Aerodrome, Cheshire

have vacancies for their newly formed

WEAPONS RESEARCH DIVISION

AERODYNAMICISTS

With Honours Degree in Physics, Mathematics or Engineering and at least two years experience are required to work in an aerodynamics group on aerodynamic theory and analysis of new weapon projects. Candidates should be familiar with supersonics.

MATHEMATICIANS

With Honours Degree to work on flight dynamics and studies of control systems. A knowledge of numerical mathematics would be an advantage.

ELECTRONIC ENGINEER

A Graduate with research and development experience in electronics or with electro-mechanical devices.

Good Salaries and Prospects

Pension and Life Assurance Scheme

Apply giving full particulars of academic training and experience to :—

A. V. ROE & CO. LIMITED,
Weapons Research Division,
WOODFORD CHESHIRE.

Small Volume Components for the Electronics Engineer

NEW

STANTELUM ELECTROLYTIC CAPACITORS

The modern trend in miniaturising communications equipment has given rise to the development of the Tantalum Capacitor which provides at relatively low working voltages a large capacitance in a very small volume.

Compare the volume percentages of the following :—

Normal Paper Capacitor (at 100 volts)	100%
Metalised Paper	65%
Aluminium Electrolytic	23%
Tantalum Electrolytic	16%

A full range of these capacitors which are hermetically sealed and suitable for operation over a temperature range of −40°C to +70°C is now available.
Stantelum Electrolytic Capacitors do not deteriorate with shelf life.

Write for Brochure BC/15 for full technical details.

STANTEL THERMISTORS

Thermistors are being used in ever-increasing numbers in the electronic and instrumentation industries where their small size and stable characteristics have provided the solution to many problems.

A wide range of both directly and indirectly heated types is available for many applications among which are included :—

- Temperature measurement and control
- Oscillator amplitude stabilisation.
- Current surge suppressors.
- Micro-wave power measurement.

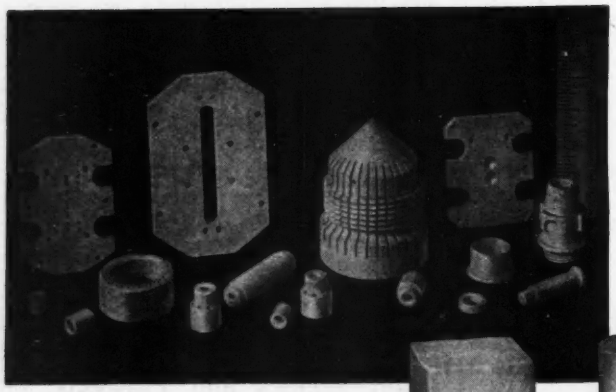
They are available with almost any value of cold resistance at 20°C with certain standardised values between the limits of 14 ohms and ½ megohm. Where low circuit resistance is essential, for example compensating the resistance increase of copper coils, Type KS2 Thermistor, having a resistance of 14Ω±10% is readily available.

Write for full technical details.

Write for full technical information

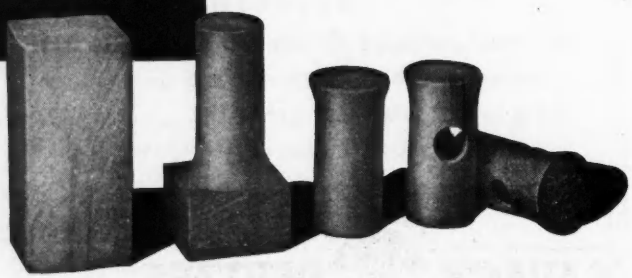
Standard Telephones and Cables Limited

INDUSTRIAL SUPPLIES DIVISION :— FOOTSCRAY SIDCUP KENT



STEATITE

... for all high frequency applications



Over a century of experience in this highly specialised field. We invite your enquiries.

Machined to special designs and fine limits.

SUGG WESTMINSTER

WILLIAM SUGG & COMPANY LIMITED

VINCENT WORKS, REGENCY STREET, WESTMINSTER, S.W.1. VICtoria 3211

"SYMEL" SILICONE

ELASTOMER IMPREGNATED GLASS FABRIC

SYMONS' ADVISORY SERVICE

If you have an electrical insulation problem, send it to us! Our Test and Research Department will be pleased to advise you.

In addition to the silicone elastomer coated glass insulation, which we have been producing now for two years, we have just begun the manufacture of Silicone Elastomer Impregnated Glass Cloth.

This material is available in thicknesses from 3 mils to 20 mils, in rolls 36" wide or in tapes of any width, and in both straight cut and bias cut form.

The bias cut tape provides a flexible Class H insulation, more suitable for taping round bends than previous materials of this type. By using an elastomer, rather than a Silicone varnish, a softer insulation is produced—one that does not crack when creased or doubled back on itself.

For tested flexible insulation—say SYMONS for sure!

H. D. SYMONS & CO. LTD.

PARK WORKS · KINGSTON HILL · SURREY · Tel. Kingston 0091 Grams. INSULATION (phone) KINGSTON-on-THAMES

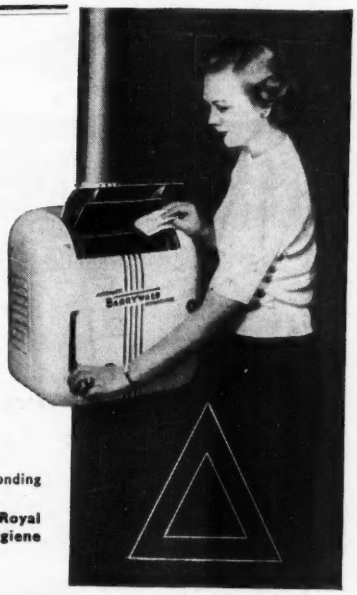
Some **MEN** *don't seem to understand* —

the importance of the welfare side from

THE WOMAN'S ANGLE

By the simple depression of a lever **THE BARRYWALD SANITARY INCINERATOR** will automatically and effectively destroy sanitary towels, surgical dressings, documents, etc., solving vital and major welfare and security problems in **FACTORIES, OFFICES, INSTITUTIONS,** etc.

Δ **The only Incinerator incorporating our Patented Safety Devices**



The **BARRYWALD** reg.

Safety Automatic Incinerator

Patent Nos. 555062-621085 and corresponding Foreign Patents

Awarded the Certificate of the Royal Institute of Public Health and Hygiene

Regularly supplied to :—All H.M. Government Departments ; War Office ; R.A.F. ; Admiralty. Local Administration & Educational Authorities. Hospital Management Committees. General Industry.

FULLY GUARANTEED FOR ONE YEAR

Economical : Efficient : Foolproof : Indispensable

THE FOREMOST SANITARY INCINERATOR SPECIALISTS IN THE WORLD

SANIGUARD APPLIANCES *Limited*

62, LONDON WALL, LONDON, E.C.2

Telephones :—NATIONAL 8881-8882 · DIVISION OF ALLIED METALS LTD

'PROVING'

outstanding success of

RAGOSINE

anti-scuffing paste

Based on Molybdenum Disulphide, Anti-Scuffing Paste is the perfect dry lubricant packed in easily handled tubes. Shown below are a selection of genuine user reports which illustrate its wide range of applications, and some of the properties which make it so valuable.

Metal Working
"ANTI-SCUFFING PASTE has proved a god send

to us in our experiments with the deep drawing of Electron sheet and I have placed an order for 2-lbs. for further work . . . Anti-Scuffing Paste is infinitely superior for this work than the recommended graphite compound and makes possible phenomenally deep draws, whilst preserving completely the surface finish."

Printing
"COMPLETE SUCCESS"

Mr. C. has now had Anti-Scuffing Paste on trial for a month for the lubrication of the plunger and well of Monotype casting machine and it has been a complete success. Operating temperature is 720°F and they have previously experimented with Graphite Grease without success.

Cloth Finishers
DELIGHTED WITH THE RESULTS.

. . . has carried out four months tests and is delighted with the results . . . The lubrication of the spring clips has always been a problem, due to heat and the tendency of oil or grease to soil the fabric. Expensive brassing of the clips meant constant renewal: the use of Anti-Scuffing Paste has solved the problem from all angles.

Cigarettes and Tobacco Manufacture
"EFFICIENT LUBRICATION"

Anti-Scuffing Paste used to lubricate top rail of cable conveyor and also for roller pins. It gives efficient lubrication without any danger of contamination of tobacco which was a frequent cause of difficulty in the past when a conventional grease was used.

Aircraft
"MANY APPLICATIONS"

Turbine Disc Bolts on Jet Engines . . . Easy removal even though subjected to temperatures above 550°C. Shrink fitting of Bolts . . . Prevents galling or sticking. Deep Drawing and Hot Stamping . . . Anti-Scuffing Paste has proved the answer. Engine Generator Shafts and Propeller Mounting Parts . . . Used as an anti-fretting agent on all shafts and parts.

Anti-Scuffing Paste may be the solution to your problem. Technical data is available from :—

ROCOL LTD.

Ibex House, Minories, London, E.C.3.
Tele : ROYal 4372 or
Minerva Works, Woodlesford, Nr. Leeds. Tele : Rothwell, Leeds, 2165.

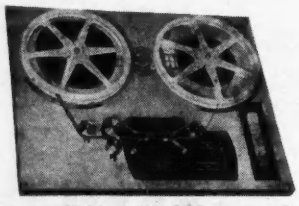
RAGOSINE
ANTI-SCUFFING PASTE

TRUVOX

TAPE RECORDING AMPLIFIER
TYPE C

16 GNS LIST PRICE

Expressly designed to **correctly** operate the TRUVOX Tape Deck Mk. III—for Recording and Playback through a 3 ohm speaker, also supplying power for erasure and biassing. Additional facilities are as (a) a pre-amplifier to feed a power amplifier for the playing of recordings at greater than normal volume (for auditorium purposes, etc.); (b) a pick-up amplifier to operate a loudspeaker direct from a gramophone pick-up; (c) a two-station radio receiver for direct listening or recording with a TRUVOX Radio Jack. **Three Input Jacks. Output:** 4 watts output at 3 ohms. **Oscillator:** Fixed frequency at approximately 45 kc/s. at high impedance. **Erase voltage** at least 150 v. **Bias** 80 v. approx. **Level indication** by Magic Eye. **Hum level:** 50 db down at 4 watts. **Frequency Response:** Fixed recording characteristic. Variable replay characteristics. Fixed level response as pre-amplifier. With TRUVOX heads and modern tapes, gives a substantially level response from 70-10,000 cps. **A.C. supply mains 110-250 v.**



TAPE DECK MARK III U

22 GNS
List Price

Now available with BSS sense of tracking. Suitable for playback of new pre-recorded tapes. Three-motor drive. "Drop-in" Tape loading. Push-button control, electrically and mechanically interlocked. Separate push-button brake. "Fast-forward" and "fast rewind" without tape wear. Silent drive eliminating "wow" and "flutter." Half-track working, and two tape speeds o 7½ inches per second, or 3¾ inches per second. Visual playing-time indicator. With a suitable amplifier, the equipment covers a frequency range from 50-10,000 c.p.s. at 7½ inches per second.

A TRUVOX PRODUCT

TRUVOX LIMITED
HARROW · MIDDLESEX

Sales Office: 15 Lyon Road, Harrow, Middlesex. *Telephone: Harrow 9282*
Technical & Service Depts. : 328 The Broadway, Station Road, Harrow, Middlesex. *Telephone: Harrow 4455*

Electrical Standards for Research and Industry

Testing and Measuring Apparatus for Communication Engineering

Unapproached throughout the world for design and accuracy

WAVEMETERS

OSCILLATORS

CONDENSERS

INDUCTANCES

RESISTANCES

BRIDGES—Capacitance Inductance Resistance

H. W. SULLIVAN
LIMITED
LONDON, S.E.15
Telephone: New Cross 3225 (P.B.X.)

CARPENTER POLARIZED RELAYS

have these outstanding features

HIGH OPERATIONAL SPEED • HIGH SENSITIVITY
FREEDOM FROM CONTACT REBOUND
NO POSITIONAL ERROR • HIGH CONTACT PRESSURES
EXCEPTIONAL THERMAL STABILITY • EASE OF ADJUSTMENT • ACCURACY OF SIGNAL REPETITION

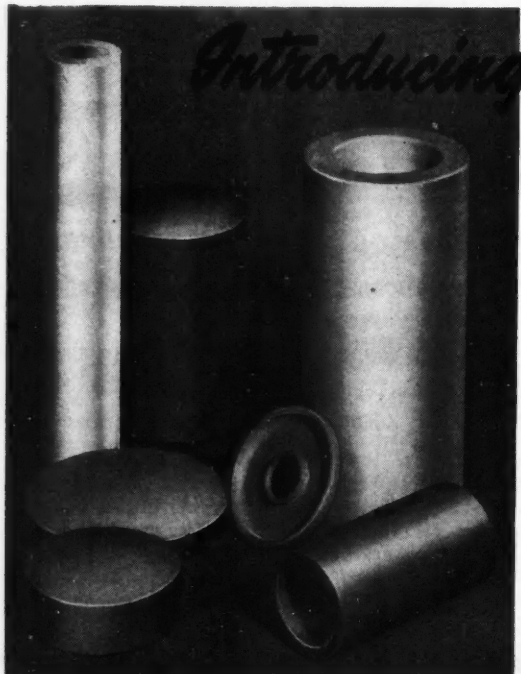
The Carpenter Polarized Relay will respond to weak, ill-defined or short-duration impulses of differing polarity, or it will follow weak alternating current inputs of high frequencies and so provide a continuously operating symmetrical changeover switch between two different sources. Five basic types are available with a wide range of single and multiple windings. Particulars of the type best suited to your purpose will be gladly supplied if you will send us your circuit details.

Manufactured by the sole licensees

TELEPHONE MANUFACTURING CO. LTD

Contractors to Governments of the British Commonwealth and other Nations

TMC **HOLLINGSWORTH WORKS, DULWICH, LONDON, SE21**
Telephone GIPsy Hill 2211



'UNIPIEZO'

THE NEW ELECTRO-TECHNICAL CERAMIC BY

U.I.C.

U.I.C. pioneers in the production of technical ceramics, now present 'UNIPIEZO'—a new Piezo-electric ceramic that is unequalled both in quality and performance.

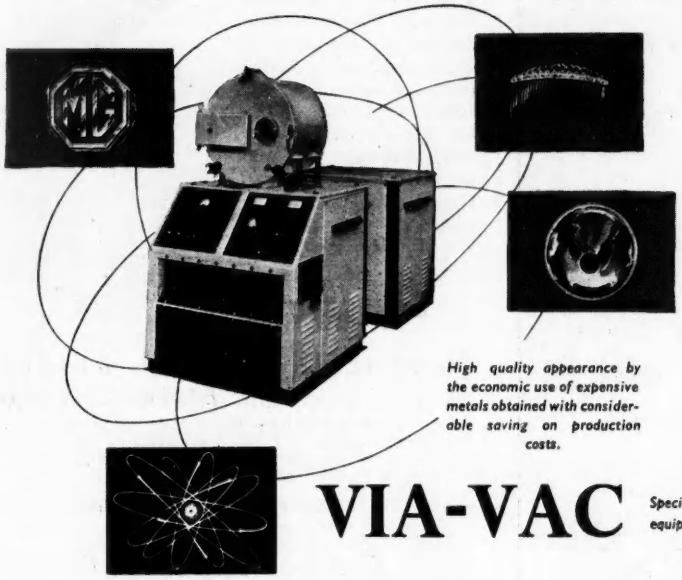
Its applications in the electronic and ultrasonic fields are unlimited and it will be of interest to all who wish to convert a mechanical displacement into an electrical response and vice versa.

A standard range of 'UNIPIEZO' elements is available and special designs can be made to order.

Write for full details to Dept. MRC.

UNITED INSULATOR COMPANY LTD. OAKCROFT RD. TOLWORTH, SURBITON, SURREY
Telephone: ELMBRIDGE 5241

Thin Films ... COATINGS WITH V.I.A. HIGH VACUUM PLANT



Fast processing cycles economically use expensive metals.

The Coating Unit illustrated is one of the V.I.A. range which has been developed for high vacuum processing. Single or multiple layers can be applied and may be used for large scale production on mirrors, plastic jewellery, lenses, reflectors and the deposition of decorative metallic films on specialised products.

High quality appearance by the economic use of expensive metals obtained with considerable saving on production costs.

VIA-VAC

Specialist manufacturers of industrial vacuum equipment — consulting service to industry.

VACUUM INDUSTRIAL APPLICATIONS LTD., WISHAW LANARKSHIRE

FUSE MOUNTING?

—see the **SLYDLOK** people

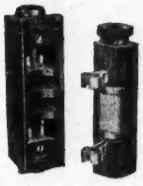
"X" SERIES VIBRATION PROOF FUSES

Five types in 5, 15, 30 and 60 amp. sizes are available to suit all requirements of wiring, connecting, and mounting. Vibration proof SLYDLOK "X" type fuses are renowned for their compactness, resistance to mechanical shock, and ease of mounting and wiring. Send for leaflet EW39 which contains full specifications.

DELIVERIES FROM STOCK

"G" TYPE FUSES

Vibration proof, sizes 15, 30, 60 and 100 amp. Ratings for 250/500 volts with rewireable fuse-links, or H.R.C. cartridges. Leaflet EW40, sent on request, gives full details.



EDWARD Wilcox & CO. LTD., WYTHENSHAWE, MANCHESTER

Telephone: Wythenshawe, 2235/6/7. *Telegrams: "Slydlox," Manchester*

LONDON: Fulwood House, Fulwood Place, W.C.1. Tel: Chancery 2206

dm EW.53

HIGH GRADE

ELECTRICAL RESISTANCE WIRES & TAPES

NICKEL–CHROMIUM
NICKEL–CHROMIUM–IRON
COPPER–NICKEL
also
PURE NICKEL
in the Hard Drawn, Bright Annealed or Oxidised Annealed Finishes

SPECIALISTS IN FINE AND SUPERFINE WIRES

IN SIZES FROM ·010"—·0005" DIA.

Technical Booklet on application :—

ALLOY WIRE CO., LTD.

LAWRENCE LANE, OLD HILL, STAFFS
Telephone : CRADLEY HEATH 6575
Telegrams : WIRELOY–CRADLEY HEATH

KLYSTRON SUPPLY UNIT

for operation of high voltage valves (Types C.V.129 and C.V.323)

- Tunable square wave modulation control on 400, 1000 or 2000c/s. Mark space ratio 1 : 1 with preset control for some variation of this ratio.
- High stability of frequency and voltage against variations in mains voltage and load current.

SELECTIVE AMPLIFIERS

- 400, 1000, 2000c/s instruments for micro-wave measurements.
- 5, 10, 20c/s high gain instruments for thermo-couple or bolometer applications, etc.

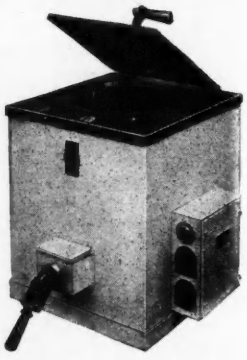
BARR & STROUD, LTD.

ANNIESLAND, GLASGOW, W.3
15 Victoria Street, London, S.W.1

Designed for

HARD-TO-HEAT COMPOUNDS

This ' B-W ' Standard auto controlled Electric Kettle is just one example from our wide range of industrial heating equipment. These kettles are fitted with a heated outlet valve and are supplied in many sizes with or without stirring gear. Heated pots and tanks of all types also available. Write for details today.



★

'B-W'

Electric INDUSTRIAL KETTLES

ALL MODELS FITTED WITH **AUTO-CONTROL**

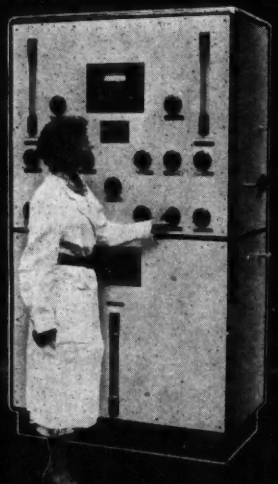
'B-W' STANDARD PRODUCTS INCLUDE :

★ FURNACES ★ OVENS
★ GLUE HEATERS ★ WAX TANKS
★ DIP POTS ★ HUMIDITY CABINETS

INDUSTRY NEEDS HEAT — YOU NEED 'B-W'

Barlow-Whitney

All enquiries to SALES OFFICE :
2 DORSET SQUARE, LONDON, N.W.1. AMBassador 5485
WORKS : **NEASDEN & BLETCHLEY**



high quality water for the production of cathode ray tubes, electrolitics, etc.

DEMINERALISED WATER EFFLUENT

CONDUCTIVITY below 3 m.mhos
T.D.S. below 2 p.p.m.
CARBON DIOXIDE practically nil.
SILICA CONTENT 0·03–0·05 p.p.m.

COLBORNE
ION EXCHANGE PLANT

for further particulars write to the Chemical Division of:—

THE COLBORNE ENGINEERING CO LTD
78 BOLLO BRIDGE RD ACTON LONDON W3
Cables "HYDROBORNE" LONDON TEL. ACORN 6551/2

OVER
25 YEARS
EXPERIENCE

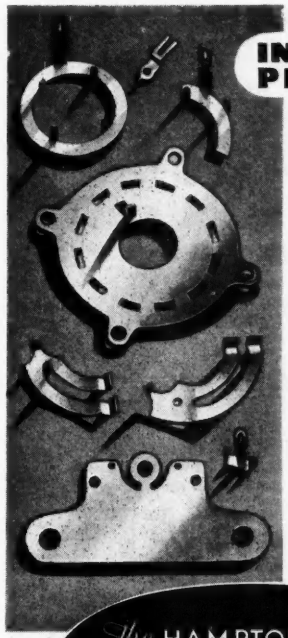
Thermo-Setting
Plastic Mouldings

We have long experience in the manufacture of small mouldings to the electrical engineering trades and are well equipped to fulfil customers' requirements promptly and economically. Costs are kept down and delivery expedited by our making all necessary moulds in our own up-to-date toolroom.

Your enquiries are welcomed and will receive our prompt attention.

HARRISON BROS
PLASTICS LIMITED
39-43, BRANSTON ST BIRMINGHAM 18

Telephone: COLmore 4270
Telegrams: "ARISUN, Phone, B'ham"



Specialists in
INSTRUMENT
PRESSINGS

At the Hampton Works we prove that there are unlimited possibilities with presswork—especially in the production of small parts for the Electronic and Electrical Industries. Our claim as master craftsman in pressings is your assurance of complete satisfaction. Every order is handled with extreme care and given prompt attention. We welcome your enquiry.

The HAMPTON WORKS
(STAMPINGS) LIMITED
PRESSWORK EXPERTS
TWYNING ROAD, STIRCHLEY, BIRMINGHAM, ENGLAND
Tel: KINGs Norton 2901 (5 lines) 'Grams: Radiagnis, b'ham

THE
INSTRUMENT
MODEL

Specially designed for soldering operations in the compact assemblies used in present day radio, television and electronic industries.
Weight 3¼ oz. (excluding flexible).
Length 9 in.
25 watts — 200/220 volts
or
220/240 volts.

Interesting features

1. Bit ⅛" diameter, simple to replace.
2. Steel cased element, also replaceable.
3. Detachable hook for suspending iron when not in use.
4. Moulded two part handle, remains cool in use.
5. Six ft. Henley 3-core Flexible.

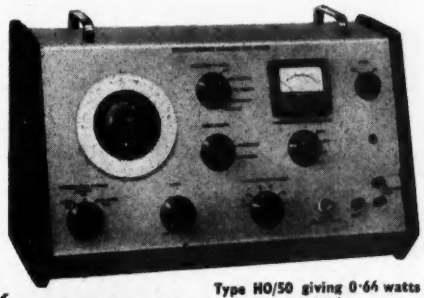
HENLEY
SOLON
ELECTRIC
SOLDERING IRONS

W. T. HENLEY'S TELEGRAPH WORKS CO. LTD.,
51/53 Hatton Garden, London, E.C.1.

INSIST ON HIFI

Type HO/500 } 20-20,000
Type HO/50 } cycles
Type HO/500A } 20-40,000
Type HO/50A } cycles

for Precision Oscillators



Hifi
REG'D TRADE MARK

Type HO/50 giving 0·64 watts output
Type HO/500 giving 5 watts output
★ Scale Calibration Accuracy of 1%
★ Supplied in 2 Standard Frequency Ranges.
★ Output Voltmeter Fitted.
★ Built-in Attenuator.
★ High and Low Impedance Output.

Look for the Registered Trade Mark

Hifi Ltd. DERRY ST., BRIERLEY HILL, STAFFS.
Telephone: Brierley Hill 7604

POLISHING MOPS

Coopers Calico Mops can be supplied in any diameter and thickness, loose or stitched, and suitable for tapered or parallel spindles. There is a good economy range of section mops, too. Each quality can be supplied in grades to suit the class of work.

POLISHING BOBS

Coopers are the original makers of the Felt Polishing Bob as used today, and today Coopers offer a wide range of bobs which includes the ideal wheel for every class of work, in six grades from soft to rock hard, and in four qualities. Send today for details of the entire bob and mop range.

COOPERS FELT

Please send enquiries to Head Office and Works :—

COOPER & CO. (B'HAM) LTD.

BRYNMAWR, BRECONSHIRE

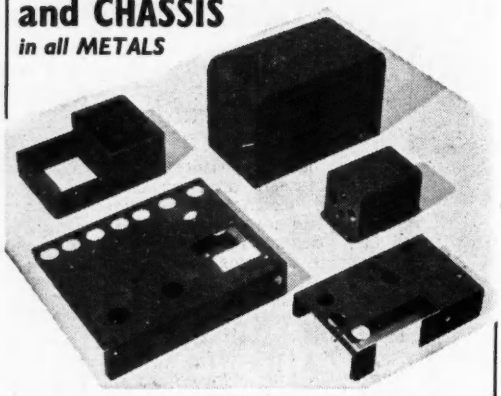
Telephone : Brynmawr 312 *Telegrams :* Felting Brynmawr

Registered Office and Works : **Little King St., Birmingham**

Manufacturers of all types of

INSTRUMENT CASES and CHASSIS

in all METALS



GENERAL SHEET METAL WORK

for the Trade

CHASE PRODUCTS (Engineering) LTD

27 PACKINGTON RD., SOUTH ACTON, W.3

Acorn 1153-4 *and at LEEDS*

CANNING *Plant and materials*

FOR PERFECT FINISHING

The high precision of all electronic equipment demands perfection from the design stage to the finish of each component.

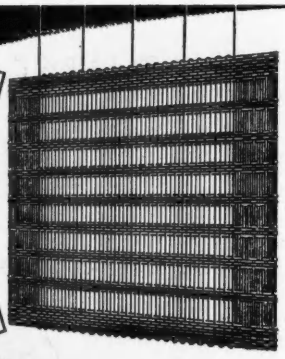
This high standard is assured by the use of Canning electroplating and polishing equipment and materials.

CANNING & Co. Ltd. BIRMINGHAM 18. LONDON & SHEFFIELD

LIGHT WEIGHT

RESISTANCE GRIDS and NETS

ASBESTOS WOVEN



THE steadily increasing demand for CRESSALL Asbestos Woven Resistance Grids and Nets is proof of their pre-eminence in this type of resistance unit. The nets are light in weight, rigid, and vibration and shockproof, and are made from the most carefully selected materials. We offer a range of standard sizes to meet almost any requirement for a single resistance unit or a banked assembly. Illustrated catalogue can be supplied on request.

CRESSALL

Registered trade name of

THE CRESSALL MANUFACTURING CO. LTD.

TOWER STREET · BIRMINGHAM 19

Telephone: ASTon Cross 2666 (3 lines) *Telegrams:* OHMIC, Birmingham

*ULTRA LOW
capacitance & attenuation

38 STOCK TYPES
for your
STANDARD or SPECIAL
APPLICATIONS

TYPE	μμ F/ft	IMPED.Ω	O.D.
C 1	7.3	150	.36"
C 11	6.3	173	.36"
C 2	6.3	171	.44"
C 22	5.5	184	.44"
C 3	5.4	197	.64"
C 33	4.8	220	.64"
C 4	4.6	229	1.03"
C 44	4.1	252	1.03"

TRANS RADIO

U.G. CONNECTORS—R.G. CABLES

TRANSRADIO LTD. 138A Cromwell Rd. London S.W.7. Tel: FRE 4421

To Designers and others interested in . . .

★ **Alloys for Glass to Metal Seals** with Expansion Co-efficients to absolute Values

★ **Pure Metals and Alloys** for Vacuum, Thermionic and X-Ray Tube manufacture

★ **Bi-Metals and Thermo-Expansion Alloys**

★ **Electrical and High Temperature Resistance Wires, Strip and Tapes**

IMPORT DIVISION OF . . .

The TETRA Engineering Co., Ltd.

Representing

HERAEUS VACUUMSCHMELZE A.G. and ISABELLEN HUETTE

(*Makers of the Original Manganin Alloy*)

1-3 REDHILL STREET, LONDON, N.W.1.

Telephone : EUSton 3707 PBX Telegrams : Tetcraft, Norwest, London

Counting by VEEDER-ROOT

COUNTERS FOR EVERY INDUSTRY

BACKED BY 70 YEARS EXPERIENCE

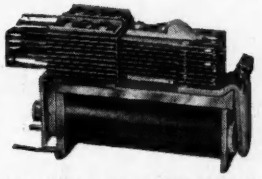
Please write for illustrated folder "EL" giving details of full range. Representative will call upon request.

REGD. TRADE MARK
Veeder-ROOT LTD.
DUNDEE
Phone No. 85218

The Name that Counts!

London Office
20 PURLEY WAY, CROYDON, SURREY
Telephone THORNTON HEATH 3477-8

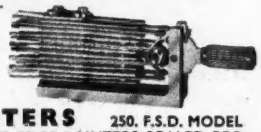
RELAYS P.O. TYPE 3000



BUILT TO YOUR SPECIFICATION
QUICK DELIVERY
KEEN PRICES
QUOTATION BY RETURN

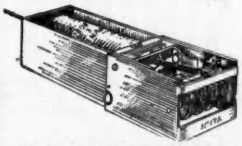
RACKS P.O. STANDARD or 19 inch panels.
Steel channel sides, correctly drilled, heavy angle base. Height: 4ft. 10ins. or 6ft. or 7ft. 2ins.

KEY SWITCHES
PROMPT DELIVERY OF ALL TYPES



MICROAMMETERS 250. F.S.D. MODEL S37 3½" FLUSH TYPE. KNIFE EDGE POINTERS SCALED FOR TEST METERS 55/-

ELECTRO-MAGNETIC COUNTERS
AS USED BY THE G.P.O. COUNTING UP TO 9999



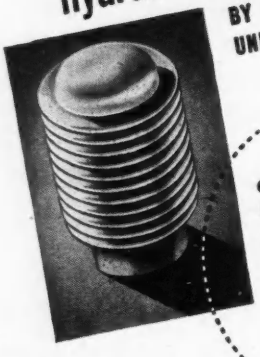
	TYPE 9G.	TYPE 17A.
	500 ohms	3 ohms
	24/50 Vt. D.C.	2/6 Vt. D.C.
	15/- Post 1/-	15/- Post 1/-

MANY OTHER TYPES IN STOCK. *LIST AVAILABLE*

L. WILKINSON (CROYDON) LTD.
19, LANSDOWNE ROAD, CROYDON
Phone : CRO 0839 *Telegrams :* "WILCO" CROYDON

hydraulically formed

BY A PROCESS UNIQUE IN THIS COUNTRY



COMBINING THE PROPERTIES OF

1. A compression spring capable of repeated flexing
2. A container which can be hermetically sealed
3. A packless gland

for Automatic coolant regulation: Movement for pressure change: Packless gland to seal spindle in high vacua: Reservoir to accept liquid expansion: Dashpot or delay device: Barometric measurement or control: Pressurised couplings where vibration or movement is present: Dust seal to prevent ingress of dirt: Pressure reducing valves: Hydraulic transmission: Distance thermostatic control: Low torque flexible coupling: Pressure sealed rocking movement: Pressurised rotating shaft seals: Aircraft pressurised cabin control: Refrigeration expansion valves: Thermostatic Steam Traps: Pressure amplifiers: Differential pressure measurements: Thermostatic operation of louvre or damper.

Write for List No. M 800-1 B13

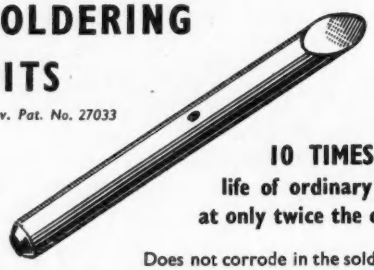
DRAYTON metal bellows

The Drayton Regulator and Instrument Co. Ltd., West Drayton, Middlesex

"FEROCOTE"

SOLDERING BITS

Prov. Pat. No. 27033



10 TIMES the life of ordinary bits at only twice the cost!

Does not corrode in the soldering iron. Will not damage the iron on removal for renewing bit.

Supplied in following sizes :—

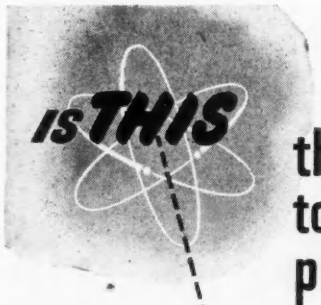
$\frac{1}{8}$" $\frac{3}{16}$" $\frac{1}{4}$" $\frac{5}{16}$" diameters.

FEROCOTE PRODUCTS

PRECISION ENGINEERS

147, Askew Road, Shepherds Bush, W.12

Tel : Shepherds Bush 4083



the answer to *your* problem?

'SINTREX' Electrolytic Iron Powder has solved many problems in electronics. Its exceptional purity gives it excellent electro-magnetic properties—ensuring high permeability and low losses in components such as small transformer cores, pole pieces, etc., for radio, T.V., fluorescent units, measuring instruments and much other equipment.

'SINTREX'
ELECTROLYTIC IRON POWDER

GEORGE COHEN SONS & CO. LTD
BROADWAY CHAMBERS · LONDON · W.6
Telephone: Riverside 4141

THE 600 GROUP OF COMPANIES

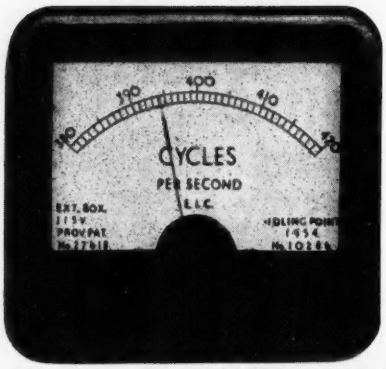
EE/533/IP3

FREQUENCY METERS

SIZES : 2½" to 8"

UP TO 5000 CYCLES

PROMPT DELIVERY



also the new **SYNCHROSCOPE**
M.C. KILOVOLTMETERS
and full range of Switchboard Instruments.

Ask for illustrated Catalogue

THE ELECTRICAL INSTRUMENT CO. (Hillington) LTD.

HILLINGTON, GLASGOW

London stockists, H. A. Patterson, 156 High Holborn

ELECTRONIC ENGINEERS

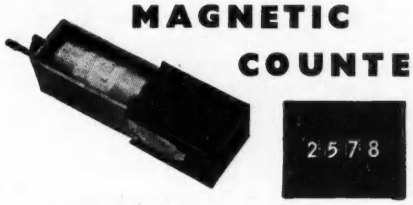
An exceptional opportunity exists for research and development engineers, wishing to work in a rural area of S.W. England. The posts are permanent, pensionable and carry top rate salaries. Houses and flats are available. The working conditions are ideal, the laboratories being housed in a new building designed for the purpose, close to a well-known country town in the heart of one of the most attractive districts. The work offers the maximum amount of interest, being concerned with a new super-priority Government Development Project undertaken by a Company famous in the electronic industry. The vacancies are for:

1. **SENIOR ENGINEERS,** with good academic background in physics or engineering and 7-10 years experience of research or development, covering a wide range of electronic techniques, but special knowledge of VHF aerial design, or design of light Electro Mechanical units would be an advantage.
2. **ENGINEERS,** as above, but applicants with more limited experience will be considered.
3. **JUNIOR ENGINEERS** with a degree or equivalent in physics or engineering. Previous practical experience not essential.

Applications should be made, in strict confidence, with full details, to Box No. W 2689

ED.1.

ELECTRO-MAGNETIC COUNTER



MAJOR TYPE 6 × 1½ × 1¼ ins.

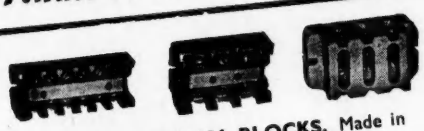
FOR ALL D.C. VOLTAGES TESTED and GUARANTEED

17/6 Post & Pkg. 9d.

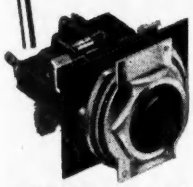
MAGNETIC RELAYS
UNISELECTORS
KEY SWITCHES

JACK DAVIS (RELAYS) LTD.
Dept 'E' 36 PERCY STREET, LONDON, W.1
MUSEUM 7960 LANGHAM 4821

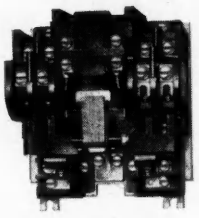
DONOVAN ACCESSORIES— FOR THE ELECTRONIC APPARATUS MANUFACTURER!



TYPE J.96 TERMINAL BLOCKS. Made in 15, 30 and 60 amp. sizes.



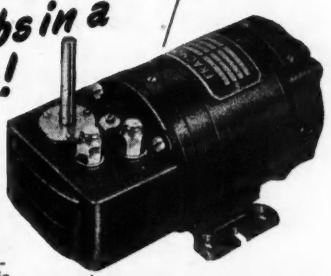
Type C.30 PUSH-BUTTON UNIT arranged for mounting on customers' own cover plate. N.O./N.C. contacts. 4 Colours.



A.C. POWER RELAY
2 to 8 Pole. N.O. or N.C. contacts.

THE DONOVAN ELECTRICAL CO. LTD.
Safuse Works · Stechford · Birmingham 33

We go for the little jobs in a big way!



As one of the largest specialists in the design and manufacture of small electric motors, we have the resources which usually enable us to provide the best solution to any problem in this field. It will pay to consult us **first!**

Illus.: Type 335C40 Geared Motor, with A.C. & D.C. interchangeable frames. 1-20 r.p.m. Torque: 20-10 lbs. ins.

There's a FRACMO for your job!

The very wide range of **"FRAMCO"** *Motors include:*

UNIVERSAL 1/250 to ¼ h.p. ● **SINGLE, SPLIT PHASE** 1/100 to ¼ h.p. & **CAPACITOR** 1/80 to 1/6 h.p. ● **3-PHASE** 1/20 to 1/3 h.p. **SYNCHRONOUS** 1/100 to 1/16 h.p. ● **SHADED POLE** 1/160 h.p. at 1300 r.p.m. ● **GEARED UNITS** 0.25 to 600 r.p.m. Torque up to 800 lbs. ins.

FRACTIONAL H.P. MOTORS LIMITED
Rookery Way, Hendon, N.W.9 Tel: Colindale 8022/3/4
Our Birmingham address is:
6 Lansdowne Road, Erdington, Birmingham 24. Tel. Erdington 0460

PROTOTYPE OR PRODUCTION

Every type of electrical component from a small contact to a complete chassis can be plated by IONIC in large or small quantities with silver or other precious metals. Waveguides and other precision components are electroformed and a variety of metals are plated on porcelain, plastics and aluminium. In addition to these special facilities IONIC have one of the most extensive general plating plants in the country.

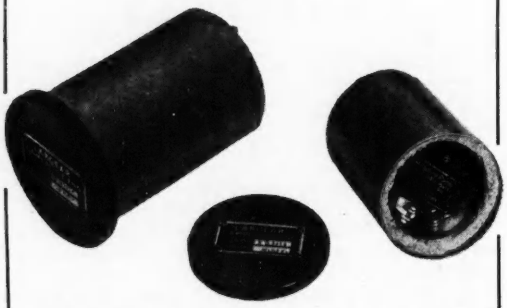
Whatever your requirements consult

IONIC

IONIC PLATING CO. LTD.
GROVE STREET, BIRMINGHAM, 18

CRYSTAL OVEN

TYPE E5101



A temperature controlled oven for quartz crystals (10X, 10XJ or B styles).

- ★ Temperature differential 1.5°C.
- ★ 6.3V. heater—11 Watts.
- ★ Adjustable thermostat.
- ★ Visual indication of thermostat operation.
- ★ Small size—low cost.

WRITE FOR LEAFLET E.E.5101 to :—

Labgear (Cambridge) Ltd.

WILLOW PLACE, CAMBRIDGE

'Phone : 2494-5 — 'Grams : LABGEAR, CAMBRIDGE

PROTOTYPES

To Designers and others interested in

PRECISION WAVEGUIDE EQUIPMENT

We Manufacture to Customers' Drawings

STANDING WAVE DETECTORS
ECHO BOXES
WAVEMETERS
HYBRID JUNCTIONS
PRECISION & PAD ATTENUATORS
MICROMETER DRIVES

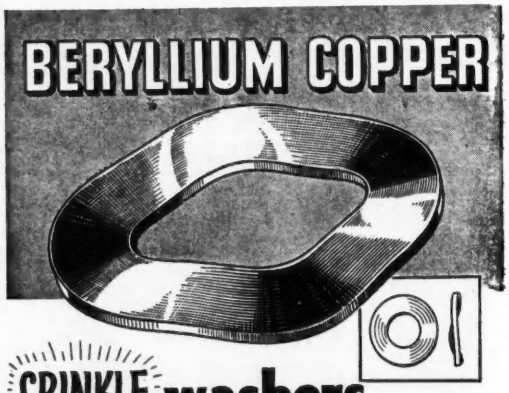
and

All Types of Precision Mechanical Apparatus

Please send enquiries to :—

LEVITT PRECISION COMPONENTS LTD.,
PROGRESS ROAD,
SOUTHEND INDUSTRIAL ESTATE,
EASTWOOD, Essex.

BERYLLIUM COPPER



CRINKLE washers

Heat treated and plated, giving corrosion resistance with high degree of recovery in relation to load, and resistance to "set". Spring locking action suitable for electronic and instrument components. Size range ¼" to 8 B.A.

Prices and samples sent on request.

CONTRACTORS TO THE ADMIRALTY • MINISTRY OF SUPPLY • & OTHER GOVERNMENT DEPTS

TRADE MARK

DAVID POWIS & SONS LTD

EDWARD WORKS SPARKBROOK BIRMINGHAM PHONE VIC 1264-8

A. V. ROE
& COMPANY LIMITED

have the following vacancies for Electronic and Mechanical Engineers in their Weapons Research Division at Woodford :

(a) Senior Engineer with Honours Degree and considerable experience of development of electronic computors or simulators to take charge of a Group developing guided weapon simulators.

(b) Senior Engineer with Honours Degree and considerable developing experience to take charge of a Group developing hydraulic and pneumatic servo and precision mechanical devices.

(c) A number of engineers with either Honours Degree in Physics or Engineering or appropriate research or development experience to work on guided weapon computing navigation and control systems.

Salaries will be commensurate with ability and experience Applications giving full particulars of age, qualifications and experience, etc, should be addressed to :—

The Chief Engineer,
Weapons Research Division,
A. V. Roe & Company Limited,
Woodford, Cheshire.

For clean, noise-free recordings—the

LeeRaser

Tape De-magnetiser

Type B (up to 7" dia.) £9 10 0

Type C as illustrated, for all sizes £15 0 0

As supplied to B.B.C. and leading Recording Studios

LEEVERS-RICH EQUIPMENT LTD.

Please note new address :

78 HAMPSTEAD RD., LONDON, N.W.1. EUSton 1481

MAGSLIPS

FOR

AUTOMATIC PROCESS CONTROL
REMOTE CONTROL
ELECTRICAL COMPUTATION
REMOTE INDICATION
PRECISION VARIABLE PHASE SOURCES
SINE WAVE GENERATION
CIRCULAR TIME BASES

DETAILS OF MAGSLIPS AS WELL AS SELSYNS, IPOTS, INSTRUMENT GEARS, SINE-COSINE POTENTIOMETERS, VELODYNES, TORQUE AMPLIFIERS, BALL AND PLATE INTEGRATORS, ETC., ARE CONTAINED IN OUR CURRENT BROCHURE.

Servo and Electronic Sales Ltd.

1, HOPTON PARADE, STREATHAM HIGH ROAD, LONDON, S.W.16, ENGLAND

STREATHAM 6165 E.E.12

SPEARETTE

TYPE W

VALVE RETAINERS
FOR
MINIATURE VALVES

SIMPLE — EFFICIENT

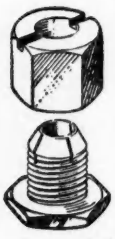
SPEAR ENGINEERING CO. LTD.
WARLINGHAM · SURREY

PRE-SET CONTROL LOCK

Designed to lock the spindles of pre-set potentiometers or trimmers without rotational or lateral displacement of shaft. Will accept wide range of panel thicknesses.

TYPE P — Very attractive appearance for panel mounting.

TYPE C



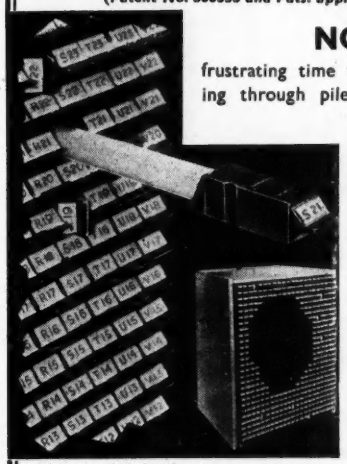
SEND NOW FOR LEAFLET L3

SUTTON COLDFIELD ELECTRICAL ENGINEERS
CLIFTON STREET, SUTTON COLDFIELD. **Phone : 5666**

EVERY DRAWING . . . .
. . . . at your FINGERTIPS
with

'PLANSTORE'

(Patent No. 588335 and Pats. applied for)



NO frustrating time wasting searching through piles of drawings.

IMMEDIATE Location and Withdrawal Visual indication shows whether drawing is " in store " or " in use."

Robustly constructed yet light in weight and economical in floor space. Units to hold approx. 300, 600 or 1,200 plans.

Write for full details to :—

JAMES H. RANDALL & SON, LTD.
(Dept. E.E.12.) Paddington Green Works, London, W.2.
AMBassador 1661 (6 lines)

Solder with LITESOL

REGD. TRADE MARK

THE LIGHTWEIGHT CHAMPION

NO TRANSFORMER NECESSARY. FOR MAINS OR LOW VOLTAGES.

Rapid Heating—Extreme Lightness—Eight different models—Bit sizes, 1/8", 3/16", 1/4", 3/8"—Prices from **19/6.** A precision instrument for discerning craftsmen.

Details of full range in folder No. S.6 sent on request.

Sole Manufacturers and Distributors :

LIGHT SOLDERING DEVELOPMENTS LTD.
106, GEORGE ST., CROYDON, SURREY. Tel: CROydon 8589

PROGRESS . .

The result of splendid effort !

P.V.C. AND POLYTHENE SLEEVINGS INSULATED WIRES AND FLEXIBLES

British enterprise, energy and ingenuity produced the Jet Engine . . . There is no limit to British achievements . . . There is also no end to the Insulating Sleevings which we produce for many Industrial applications.

A.I.D. Approved.

PLASTICABLE LIMITED

Hawley Lane · Farnborough · Hants.

Phone : Farnborough Hants 85.

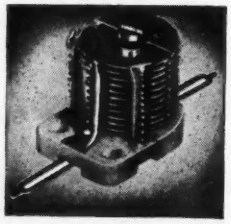
Excellence in design . .

Specialists in Subminiature Telecommunication Components

AIR DIELECTRIC TRIMMERS

70pF

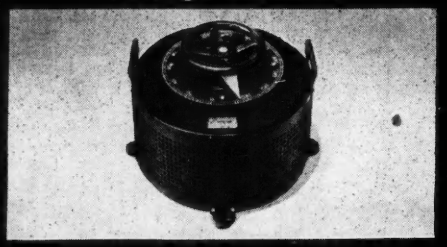
Illustration (approx.) actual size



Type approved Cat.A No. 464
12 Vane type, 500 Volts
Width 16·5mm.
Length 22mm.
Height 19mm.
Insulation 10,000 megs.
Power Factor less than ·001
Temp. Coeff.:
50 parts/million/°C.

OXLEY DEVELOPMENTS CO. LTD.
ULVERSTON, NORTH LANCS.
Tel. ULVERSTON 3306.

VARIACS for S-M-O-O-T-H Voltage Control



The "VARIAC"† is the original, continuously adjustable auto-transformer . . . the ideal control for varying the a-c voltage applied to any electrical, electronic, radar or communications equipment.

Voltages from Zero to 17% above line are obtained by a 320-degree rotation of the shaft, which is equipped with a direct-reading dial, calibrated accurately.

"VARIAC" offers many real advantages over any other type of a-c control: compared with the losses of resistive controls they save their initial cost within about one year. They are available in various sizes from 170 VA up to 25 Kilowatts. 3-gang assemblies are also available for 3-phase working. Prices vary from £7.10.0. upwards.

Write for our Catalogue—Technical Manual V-549, which gives all possible information, to:

CLAUDE LYONS LTD.

Electrical and Radio Laboratory Apparatus etc.

HEAD OFFICE AND WORKS: 76 OLDHALL STREET, LIVERPOOL 3, LANCS.
SOUTHERN FACTORY: VALLEY WORKS, WARE ROAD, HODDESDON, HERTS.
(A 10 main London/Cambridge Road, at Junction of A.602)

INSULATION

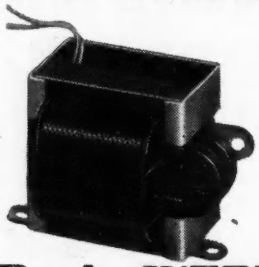
Our products include—
Presspahn and Leatheroid ; Pressboard ; Vulcanized Fibre ; Cable and Red Rope Paper ; Bakelite and Ebonite ; Varnished Paper and Tapes ; Varnished Silks and Tapes ; Varnished Glass and Tapes ; Varnished Cambric, Silk, Glass and P.V.C. Sleevings ; Cotton Tapes, Webbings and Sleeving ; Chatterton Compound ; Adhesive and Rubber Tapes.

PRESSPAHN, LTD.
Bradford, Yorks, England
Established 1900

REGISTERED ELECTRICAL WELLSTEAD INSULATION TRADE MARK

Telephone :
Bradford 25135 (Pvt. Br. Ex.)
Telegrams & Cables :
"Presspahn, Bradford"

A. C. SOLENOID TYPE SC.

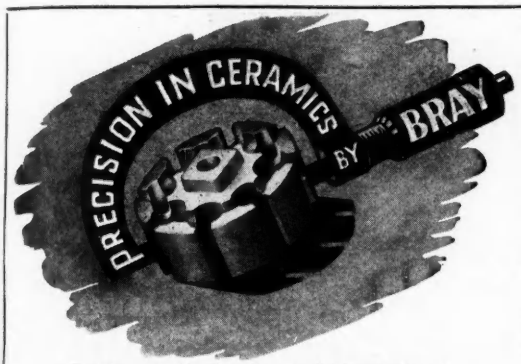


Continuous 3 ozs. at ½"
Instantaneous to 39 ozs.

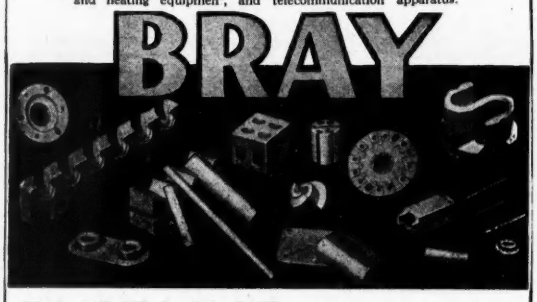
100% PRODUCTION INSPECTION

Larger Sizes Available
Also Transformers
to 6 KVA 3 Phase.

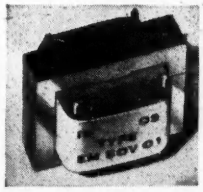
R. A. WEBBER LTD.
18 FOREST ROAD, KINGSWOOD, BRISTOL. Phone : 74065



Quantity production of small automatically made pieces in Steatite, Porcelain, and Rutile materials for electric cooking and heating equipment, and telecommunication apparatus.



GEO. BRAY & CO. LTD., Leicester Place, Leeds 2.
Tel.: 20981/9. *Grams.*: "Bray, Leeds"



BELCLERE
MINIATURE
Input, Output and Interstage
TRANSFORMERS

We specialise in the manufacture of coupling transformers to customers' requirements. An illustrated brochure describing the range of transformers we manufacture will gladly be sent on request. Illustrated above is a standard input transformer type "E" size 1" × ⅞" × ⅞" overall, available with varnish dip finish, encapsulated block form, or in mu-metal screening can.

Quick delivery— low prices—maximum efficiency.

JOHN BELL & CROYDEN, 117 HIGH STREET, OXFORD
Telephone: 47072 ● Cables: Belclere, Oxford

If you need

a small **METAL PRESSING**
for your product, why not consult us?

● ● ●

We specialise in light precision presswork in all metals for the Electrical Trades

QUOTATIONS BY RETURN

BIRMINGHAM SPECIALITIES LTD.
80-81 BATH STREET BIRMINGHAM 4
Phone: CENTRAL 2492

PLASTIC MOULDERS

A.I.D. Approved

Phone High Wycombe 1921/2

COMPRESSION
TRANSFER
INJECTION

Over 50 PRESSES
MODERN TOOL ROOM

ELCO PLASTICS LTD. High Wycombe. Bucks.

ELECTRONICS
APPLIED TO INDUSTRY

The many new applications of electronics makes it vitally necessary for all in Industry to have a sound working knowledge of this subject. We offer a new Self study course intended to teach the main principles of electronics and its chief industrial applications. Experimental work can, if desired, be carried out using equipment supplied with the course.

Send for Free Brochure to:

E.M.I. INSTITUTES, Dept. E.11, London, W.4

An educational organisation serving the E.M.I. Group of Companies which include "HIS MASTER'S VOICE", MARCONIPHONE, ETC.

IC 58

Brayhead
SPRINGS
above all

Production manufacturers of torsion, tension and compression springs of all types, pressings, clips, I.F. cans, valve screening cans, valve shrouds, and sole manufacturers of the most advanced shock absorption device—"METPAKS" Shock Absorbers.

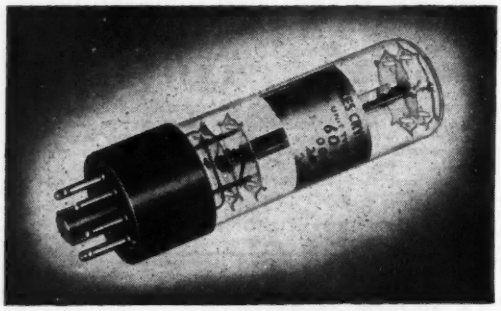
B4K

Leading manufacturers rely on:—

BRAYHEAD
SPRINGS LTD.
FULL VIEW WORKS
KENNEL RIDE · ASCOT · BERKS.

Telephone: Winkfield Row 427 · *Telegrams:* Brayhead Ascot

BROOKES *Crystals*



mean DEPENDABLE frequency control

● *Illustrated above is a Type OB Crystal unit with a frequency range of 50–110 kc/s. Frequency Tolerance ± ·005% of nominal at 20°C.*

ALL Brookes Crystals are made to exacting standards and close tolerances. They are available with a variety of bases and in a wide range of frequencies. There is a Brookes Crystal to suit your purpose—let us have your enquiry now.

BROOKES

Brookes Crystals Ltd.

Suppliers to Ministry of Supply, Home Office, B.B.C., etc.

181/3 TRAFALGAR RD., LONDON, S.E.10

Phone: GREenwich 1828 *Grams:* Xtals Green London

T1 T2

SPECIAL ADVANCE

These are the British-made
THERMO-COUPLE ALLOYS

THE RESULT OF UNIFIED CONTROL

AT EVERY STAGE OF MANUFACTURE, FROM START TO FINISH

AN immense diversity of application is being met by the British-made thermo-couple wires 'T1/T2' and 'Special Advance.'

Every operation in the manufacture of these wires, from the initial melt to the finished material, is carried out at the Cheadle plant under unified and precise control.

'T1' (nickel-chromium) and 'T2' (nickel-aluminium) are supplied to operate at temperatures up to 1100°C.

For lower temperatures the 'Special Advance' alloy is supplied for use with copper (up to 500°C.) and with iron (up to 900°C.) to users' individual requirements.

'T1/T2' and 'Special Advance'

BRITISH DRIVER-HARRIS CO. LTD

MANCHESTER 15

Nickel and Nickel Alloy Specialists: for furnace elements, domestic appliances, thermo-couples, telecommunications,, lamps, spark plugs, fine wires, etc.

"NICHROME"

ENGINEERS AND PHYSICISTS

FERRANTI LIMITED in their new Laboratories are engaged in a programme of electronic development of great industrial importance. The work involves the use of digital computers to control machines and industrial processes, and covers a wide and expanding field of application, offering long-term interest to those engaged in it.

Development activity for these projects is taking place in the fields of electronic circuitry (including pulse technique), digital computers, magnetic recording and servomechanisms. Engineers and Physicists having experience as well as interest in one or more of these subjects are invited to apply.

The appointments are permanent and offer full scope for initiative in an expanding organisation. A salary commensurate with the qualifications required will be paid. Staff Pension Scheme. Application form will be sent on request (quoting Ref. 23/EP/AL) to the

PERSONNEL OFFICER
Ferranti Limited, Ferry Road, Edinburgh 5.

BOROUGH POLYTECHNIC

Borough Road, S.E.1.

A course of ten lectures on Nuclear Particle Techniques will be given by members of the staff of the Atomic Energy Research Establishment and by physicists from London Medical Schools, on Wednesday evenings at 7.00 p.m. The first lecture will be on the 12th January, 1955. These lectures are designed for those who use Nuclear Particle Techniques and are concerned with their applications. The course fee is £2. 10s. 0d.

Further particulars and application forms can be obtained from:– The Secretary.

Development and Production of Industrial and Trade Moulding by Injection and Compression techniques. Specialists in P.V.C. mouldings, and work incorporating metal inserts for the Aircraft, Electrical and Electronic Industries.

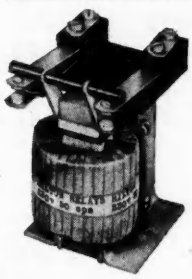
BRITISH PLASTICS DEVELOPMENTS *Ltd.*

PARKGATE · NEWDIGATE · SURREY

TELEPHONE NEWDIGATE 269

HILTON RELAYS HILTON RELAYS HILTON RELAYS

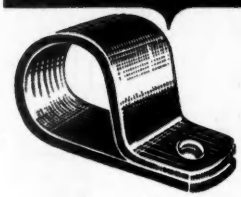
HILTON
RELAYS



HILTON
ELECTRIC CO. LTD
52 POOL ST., WOLVERHAMPTON Phone: 22783

HILTON RELAYS HILTON RELAYS HILTON RELAYS

PLASKLIP NON-METALLIC CLIPS



Provide the means for the correct securing of components and cable looms in radio and electrical instruments and equipment. The very extensive range covers wiring requirements generally. Made in high dielectric material, non-electrolytic, non-magnetic, radiused edges, fully tropical. Approved all services.

Samples and literature on request

INSULOID MANUFACTURING COMPANY LIMITED
Sharston Works, Leestone Ave., Wythenshawe, Manchester. Tel: Wythenshawe 2842

Dainite

MOULDED RUBBERS

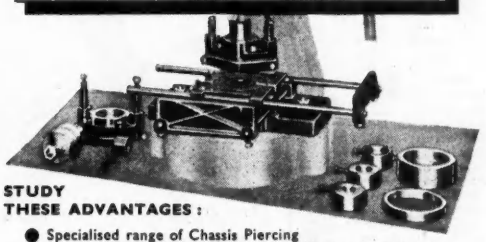
TECHNICAL SERVICE

Expert attention to special requirements

THE HARBORO' RUBBER CO. LTD., Market Harborough. Tel: 2274-5

HUNTON will cut your press tool costs for PROTOTYPE and PRE-PRODUCTION RUNS!

THE UNIVERSAL BOLSTER OUTFIT USING STANDARDISED PUNCHES AND DIES FOR SHEET METAL PIERCING AND BLANKING ON FLY PRESSES



STUDY THESE ADVANTAGES :

- Specialised range of Chassis Piercing and Forming Tools for the Radio and Electronics Industries.
- To get you started—standardised Punches and Dies ⅛" to 3⅛" dia. in 1/32" sizes *from stock*.
- At short notice, Standardised Tools for square, oblong and other shapes.
- Adjustable Gauges for exact location of work. Automatic and Positive Stripping of material from Punch.

If in London and Home Counties, ask for a practical demonstration in your own works. Alternatively, write for illustrated price List.

HUNTON LIMITED
PHOENIX WORKS, 114-118, EUSTON RD., LONDON, N.W.1. Tel. : EUSton 1477 (3 lines) Grams : Untonexh, London

LOW PRICES INSTRUMENT CASES
in Steel with light alloy panel. (18 G throughout.)

Type "9" 8"x9"x8" 18/6 Type "9-12" 9"x12"x9" 21/-
Type "12" 10½"x12"x10½" 25/-

Light alloy chassis in 18G with reinforced corners :—

6 x 4 x 2½ ... 5/6	14 x 8 x 2½ ... 13/9	10 x 8 x 2½ ... 9/6
6 x 8 x 2½ ... 8/-	16 x 8 x 2½ ... 14/9	10 x 9 x 2½ ... 11/-
10 x 7 x 2½ ... 9/-	6 x 5 x 2½ ... 7/6	14 x 9 x 2½ ... 14/-
12 x 8 x 2½ ... 10/6	10 x 6 x 2½ ... 8/6	16 x 9 x 2½ ... 15/6

High stability resistors in 1, 2, and 5% available from stock or to order. 1% condensers also stocked in limited range.

KENDALL & MOUSLEY
18, Melville Road, Edgbaston, Birmingham, 16

TECHNICAL BOOKS

H. K. LEWIS & Co. Ltd. invite inspection of their stock of books on all branches of Radio and Electrical Engineering. Catalogue on request.
LENDING LIBRARY : Technical and Scientific. Annual Subscription from TWENTY-FIVE SHILLINGS

Prospectus Post Free on Request.

THE LIBRARY CATALOGUE revised to December, 1949, containing a classified Index of Authors and Subjects. To subscribers, 17s. 6d. net. To non-subscribers, 35s. net. Postage 1s. 6d. Supplement 1950-52. To subscribers, 3s. net. To non-subscribers, 6s. net, postage 6d.

LONDON: H. K. LEWIS & Co. Ltd., 136 Gower St., W.C.1
Telephone : EUSton 4282 (7 lines)

4 reasons why...

IT PAYS TO SOLDER with

Rapid Constant Heat
Absolute Dependability
Solid Construction
Perfect Balance

Unbeatable from every point of view, well able to withstand hard workshop treatment and ideal for continuous use. Features include rapid constant localised heat—solid sturdy construction—low current consumption — perfect balance—absolute dependability. A type and bit for every purpose from fine instrument to heavy industrial work.

Each tool includes 5 feet tough rubber 3-core cable.

Obtainable from all leading tool merchants and factors. Fully descriptive Brochure free on request.

WOLF *Electric* **SOLDERGUNS AND SOLDERING IRONS**

TRIGGER FEED SOLDERGUN

Type No. 51 is designed specially for all assembly operations. Solder is fed automatically with trigger-action and two reels are supplied—one 15 ft. acid-cored and one 15 ft. resin-cored.

WOLF ELECTRIC TOOLS LTD·PIONEER WORKS·HANGER LANE·LONDON W.5
Telephone: PERIVALE 5631-4
Branches: Birmingham · Bristol · Glasgow · Leeds · Manchester · Newcastle

'Radiospares' Quality Parts

The Service Engineer's First Choice

PRESSINGS

1,000 or 1,000,000

PROMPTLY ACCURATELY & EFFICIENTLY from

PRESCOTT MANFG. CO., LTD.
SPENCER STREET, BIRMINGHAM, 18
Telephone : CENTRAL 2933

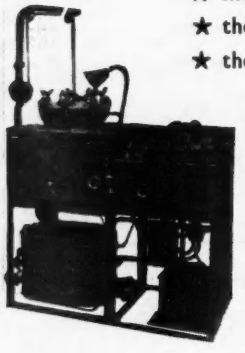
GIVE YOUR WINDINGS A GOOD LIFE

impregnate with a

BLICKVAC HIGH-VACUUM IMPREGNATOR

Full range of models available to meet the needs of

★ the large-scale Producer
★ the Research Laboratory
★ the small Rewind Shop



BLICKVAC UNITS MEET THE MOST STRINGENT SPECIFICATIONS.

Outstanding Features :

- Ease in control
- Simple attachment of auxiliary autoclaves
- Fully demountable to facilitate cleaning
- Best quality fittings throughout
- Unequalled flexibility and performance
- Units available suitable for:

VARNISH, WAX, BITUMEN POTTING RESINS

If your problem is **Coil Impregnation**
CONSULT BLICKVAC

Write today to Hamilton Road Works, Hamilton Road, S.E.27
GIPsy Hill 4394
Associated with Blick Time Recorders Ltd. Blick Engineering Ltd.

CO-AX PRECISION CONNECTORS
Better ON *all* **COUNTS**

- design
- machining
- performance
- price
- delivery

The most comprehensive range of **U.S. CONNECTORS** outside the **U.S.A.**

CO-AX Connectors
CO-AX Cables R.G. Cables
Microdual drives

TRANSRADIO LTD. 138A Cromwell Rd. London S.W.7. *Tel: FRE 4421*

INDEX TO ADVERTISERS

A

Advance Components Ltd. 18
Aero Research Ltd. 60
Airmec Ltd. 43
A.K. Fans Ltd. 12
Alloy Wire Co. Ltd. 108
All-Power Transformers Ltd. .. 14
Ashton Ltd., N. C. 86
Austinlite Ltd. 28
Automatic Coil Winder & Equipment Co. Ltd., The 16
Aveley Electric Ltd. 87

B

Baker & Finnemore Ltd. 88
Barlow-Whitney Ltd. 108
Barr & Stroud Ltd. 108
Bell & Croydon, John 117
Belling & Lee Ltd. 26
Birmingham Specialities Ltd. .. 117
Blickvac Ltd. 120
Borough Polytechnic 118
Bray & Co. Ltd., George 117
Brayhead Springs Ltd. 117
British Communications Corporation Ltd. 66
British Driver-Harris Co. Ltd. .. 118
British Electric Resistance Co. Ltd. .. 88
British Insulated Callender's Cables Ltd. 57
British Plastics Developments Ltd. .. 118
British Thomson-Houston Co. Ltd. .. 20
Brooke's Crystals Ltd. 118
Broxlea Products Ltd. 121
Brüel & Kjaer 89
Bulers Ltd. 22
Burgess Products Co. Ltd. 24

C

Canning Ltd., W. 110
Cathodeon Ltd. 34
Cementation (Muffelite) Ltd. .. 90
Chapman & Hall Ltd. 43
Chase Products Ltd. 110
Cinema-Television Ltd. 32
Clarke & Co. (Manchester) Ltd., H. 91
Clifford & Son Ltd., Charles .. 90
Cohen, Sons & Co. Ltd., George .. 112
Colborne Engineering Co. Ltd., The 108
Cole Ltd., E. K. 5
Cooper & Co. (Birmingham) Ltd. .. 110
Cossor Ltd., A. C. 29
Counting Instruments Ltd. 91
Cressall Manufacturing Co. Ltd. .. 110

D

Davis (Relays) Ltd., Jack 113
Dobbie McInnes Ltd. 92
Donovan Electrical Co. Ltd. 113
Drayton Regulator & Instrument Co. Ltd. 112

E

Edison Swan Electric Co. Ltd., The Cover ii
Egen Electric Ltd. 93
Elco Plastics Ltd. 117
Electrical Instrument Co. (Hillington) Ltd. 112
Electric Construction Co. Ltd., The .. 58
Electronic Components Ltd. 3
Electronic Engineering Monographs 42, 87 and 100
E.M.I. Factories Ltd. 30, 31, 69 and 92
E.M.I. Institutes Ltd. 117
English Electric Co. Ltd., The .. 36
English Glass Co. Ltd. 94
Enthoven & Son Ltd., H. J. 35
Ericsson Telephones Ltd. 40
Ever-Ready Co. (Great Britain) Ltd. 38
Evershed & Vignoles Ltd. 33

F

Ferocote Products 112
Ferranti Ltd. .. .. .. 37 and 118
Foster Transformers & Switchgear Ltd. 39
Fox Ltd., P. X. 42
Fractional H.P. Motors Ltd. .. 113

G

Gardner's Radio Ltd. 94
Garrard Engineering & Manufacturing Co. Ltd., The 95
General Electric Co. Ltd., The 27 and 44
General Engineering Co. (Radcliffe) Ltd. 46
Gresham Transformers Ltd. 48

H

Haddon Transformers Ltd. 97
Hampton Works (Stampings) Ltd. .. 109
Harboro' Rubber Co. Ltd., The .. 119
Harrison Bros. (Plastics) Ltd. .. 109
Hassett & Harper Ltd. 50
Henley's Telegraph Works Co, Ltd., W. T. 109
Hifi Ltd. 109
Hill Ltd., C. & L. 52
Hilton Electric Co. Ltd. 119
Hunt Ltd., A. H. 54
Hunton Ltd. 119

I

Imhof Ltd., Alfred 96
Imperial Chemical Industries Ltd. .. 41
Insuloid Manufacturing Co. Ltd. .. 119
Ionic Plating Co. Ltd. 114
Isotope Developments Ltd. 85

(continued on next page)

We can do it!

ASSEMBLING RESISTOR TAG-BOARDS for electronic applications demands a high standard of workmanship and supervision. Resistors of the correct tolerances must be selected by direct reference to drawing; special care is needed when making up "mirrored pairs"; and all soldering must pass A.I.D. inspection. . . . Our current orders embrace nearly 200 different tag-board assemblies, and operators have to be switched daily from one type to another in order to meet twice-weekly delivery requirements. . . . This is another example of the high-quality subcontracting we are qualified to undertake. Interested firms are invited to come and see us at work.

One of 200 different types of resistor tag-boards in current production.

BROXLEA PRODUCTS LIMITED

HIGH RD., BROXBOURNE, HERTS. Phone: Hoddesdon 3091/2

INDEX TO ADVERTISERS *(continued from previous page)*

K

Kendall & Mousley Ltd. 119

L

Labgear (Cambridge) Ltd. 114
Langham-Thompson Ltd., J. 82
Leevers-Rich Equipment Ltd. 115
Lewis & Co. Ltd., H. K. 119
Lewis Spring Co. Ltd. 96
Levitt Precision Components Ltd. .. 114
Light Soldering Developments Ltd. .. 116
Lion Switchgear Ltd. 84
Lyons Ltd., Claude 116

M

Magnetic Devices Ltd. 80
Marconi Instruments Ltd. 17
Marconi's Wireless Telegraph Co. Ltd. .. .. 21 and 76
Microwave Instruments Ltd. .. Cover i
Midland Silicones Ltd. 79
Muirhead & Co. Ltd. 77
Mullard Ltd. .. .. 19, 62, 78 and 81
Multicore Solders Ltd. .. Cover iv
Murex Ltd. 85

N

Nagard Ltd. 63
Neill & Co. (Sheffield) Ltd., James .. 95
New Electronic Products Ltd. .. 97
Norton & Gregory Ltd. 45

O

Oxley Developments Ltd. 116

P

Painton & Co. Ltd. 75
P.A.R. Ltd. 66
Philips Electrical Ltd. 98
Plasticable Ltd. 116
Plessey Co. Ltd., The 15
Power Controls Ltd. 74
Powis & Sons Ltd., David 114
Precision Rubbers Ltd. 7
Precision Screw & Manufacturing Co. Ltd. 89
Prescott Manufacturing Co. Ltd. .. 120
Presspahn Ltd. 116
Prestware Ltd. 73
Pye Ltd., W. G. 72

R

Radio Resistor Co. Ltd. 71
Radiospares Ltd. 120
Ragosine Oil Co. Ltd. 104
Randall & Sons Ltd., James H. .. 115
Ratcliffe (Rochdale) Ltd., F. S. .. 61
R.C.A. Photophone Ltd. 47
Redifon Ltd. 99
R.E.M.E. 98
Roe & Co. Ltd., A. V. .. .. 101 and 115
Rola-Celestion Ltd. 7
Rubber Bonders Ltd. 64
Rubber Improvement Ltd. 49

S

Salford Electrical Instruments Ltd. .. 122
Salter & Co. Ltd., George .. 23 and 70
Saniguard Appliances Ltd. 103
Sankey & Sons Ltd., Joseph 100
Savage Transformers Ltd. 101
Servo & Electronic Sales Ltd. .. 115
Servomex Controls Ltd. 13
Sheffield Smelting Co. Ltd. 99
Smith & Sons Ltd., W. H. 43
Solartron Electronic Group Ltd. Cover iii
Southern Instruments Ltd. 67
Spear Engineering Co. Ltd. 115
Standard Telephones & Cables Ltd. 25, 68 and 102
Steatite Insulations Ltd. 65
Stone-Chance Ltd. 93
Suflex Ltd. 51
Sugg Ltd., William 102
Sullivan Ltd., H. W. 105
Superflexit Ltd. 56
Sutton Coldfield Electrical Engineers 115
Symons Ltd., H. D. 103

T

Telephone Manufacturing Co. Ltd. .. 105
Tetra Engineering Co. Ltd. 111
Thompson & Norris Mnfg. Co. Ltd. 55
Thorn Electrical Industries Ltd. .. 53
Transradio Ltd. .. .. 111 and 120
Trumeter Co. Ltd. 106
Truvox Engineering Co. Ltd. 104
Twentieth Century Electronics Ltd. .. 59

U

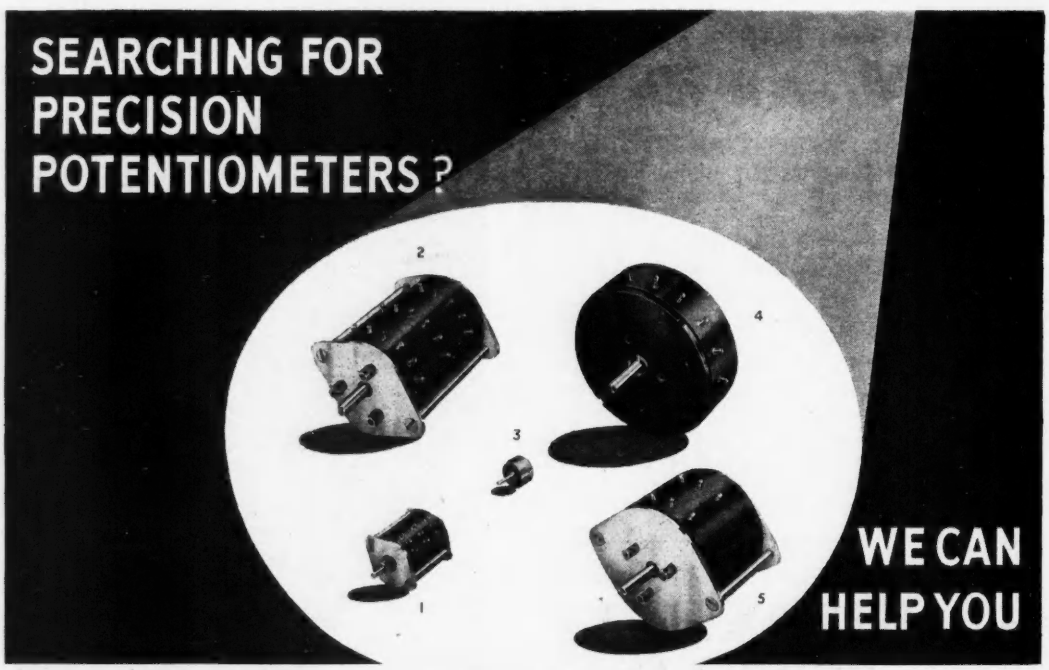
Unbrako Socket Screw Co. Ltd. .. 83
United Insulator Co. Ltd. 106

V

Vacuum Industrial Applications Ltd. 107
Veeder-Root Ltd. 111

W

Walters & Son Ltd., Austin 86
Webber Ltd., R. A. 116
Wilcox & Co. Ltd., Edward 107
Wilkinson, L. 111
Wolf Electric Tools Ltd. 120



SALFORD ELECTRICAL INSTRUMENTS LTD.
PEEL WORKS, SILK STREET, SALFORD 3. *A Subsidiary of THE GENERAL ELECTRIC CO. LTD. of ENGLAND.*

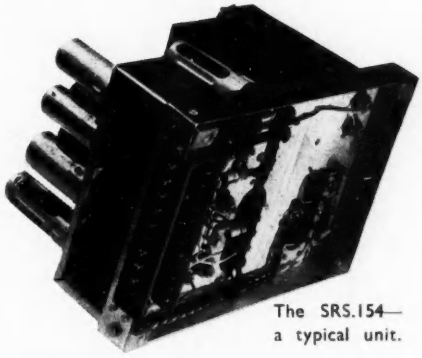
Printed in Great Britain by The Press at Coombelands, Ltd., Addlestone, Surrey, for the Proprietors, Morgan Brothers (Publishers), Ltd., 28, Essex Street, Strand, W.C.2. Registered for Transmission by Canadian Magazine Post

"Of course we always wind our own resistors—

it saves capital expenditure"

Dr. Frittertime is right, but at what a cost! Projects late, sales down, overheads up, reputations sullied. . . . .

Resistors are something of an extreme case, but the same arguments apply to Power Supplies. Are all your engineers fully aware of the range of Power Supplies we can supply? Speed up your projects by cutting out the design of Power Supplies and using our standard units.



The SRS.154—
a typical unit.

BRIEF SPECIFICATION OF SRS.154

250 volts, 50 m/a.

Source Impedance :	0.5 ohm (25c s-100 Kc/s)
Stability Factor :	400 : 1
Ripple Content :	200 μ volts
Dimensions :	6" × 9" × 6"
Price :	£30
Delivery :	Ex Stock.

Full details of our range from : Dept. E.1.

SOLARTRON ELECTRONIC GROUP LTD.

Queen's Road, Thames Ditton, Surrey. Telephone : Emberbrook 5611. Cables : Solartron, Thames Ditton.

RELIABILITY–COSTS UNDER OUR 12 MONTHS GUARANTEE HAVE NEVER EXCEEDED 0.2% OF SALES.

MULTICORE SOLDERS LTD.

RADIO & T/V SERVICE ENGINEERS' 1 LB. REELS

This special economy pack for Service Engineers contains approx. 167 ft. of 18 s.w.g. Ersin Multicore Solder. Reels 15/- each (subject)

SIZE 1 CARTONS (5/- SUBJECT)

Available in 4 specifications as below.

Catalogue Ref. No.	Alloy Tin/Lead	S.W.G.	App. Length per carton
C 16014	60/40	14	21 feet
C 16018	60/40	18	55 feet
C 14013	40/60	13	19 feet
C 14016	40/60	16	38 feet

provide the right solder

7 LB. REELS

Ersin Multicore 5-core Solder is supplied in 6 alloys and 9 gauges on 7 lb. reels for factory use. Prices on application.

SOLDER RINGS

Ersin and Arax Multicore butt-jointed solder rings in diameters from $\frac{1}{8}$"—2" and in gauges from 10—22 s.w.g. (according to diameters) are available at no extra cost.

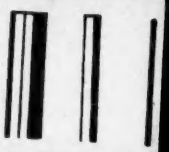
in the right gauge, with the

TAPE SOLDER

Multicore Tape Solder needs only a match to make a sound joint. On 1/- cards and, for factory use, on 3½ lb. reels in widths from $\frac{1}{8}$"—$\frac{3}{8}$" and thicknesses from .005".

ULTRA FINE GAUGES

Ersin Multicore Solder can now be supplied in 22 s.w.g. on 1 lb. reels and in even gauges between 24 and 34 s.w.g. on ½ lb. reels in 60/40 and 40/60 alloys. All gauges have 5 cores of Ersin Flux.



right flux, in the right form

LIQUID AND JELLY FLUX

Ersin Flux in liquid form is available for dipping purposes. Ask for Multicore High Viscosity Red Jelly when a flux of greater adherence is required. Size 12 tins 4/6 each (subject).

PRINTED CIRCUITS

A complete soldering process has been developed by the Multicore laboratories. Write for publication Ref. P.C.L. 100.

for every soldering need

Ersin Multicore 5-core Solder is so fast that you can often save money by using an alloy of lower tin content. The 5 cores of extra-active Ersin Flux guarantee a continuous flux stream which cleans even the most heavily oxidised surfaces at great speed and reduces the surface tension of the molten solder, causing it to wet metals rapidly. The activating agent in Ersin Flux is completely volatilised during the soldering process and the residue is pure rosin—non-corrosive, non-sticky and impervious to moisture.

If you have any soldering problems the Multicore Technical Service Department will be pleased to assist in finding the most suitable and economical solder for your particular application.

Bib WIRE STRIPPER & CUTTER

Strips insulation without nicking the wire. Cuts wire cleanly. Splits plastic extruded twin flex. Adjustable to most wire thicknesses. 3/6 each (subject).

MULTICORE SOLDERS LTD., MULTICORE WORKS, HEMEL HEMPSTEAD, HERTS. (BOXMOOR 3636)